ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

III

VOLUME II, NUMBER 1.

REVIEW OF TWO SERIES OF AMPHIBIANS

By

Richard Deckert

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

October, 1915

FIG. 1. HARLEQUIN FROGS. *DENDROBATES*

Blue-legged Frog, *D.* [illegible] Keferst.

Ornate Frog, *D.* [illegible] Schmidt. Scarlet Frog, *D.* [illegible] Cope.

Richard D. [illegible] phot.

FIG. 2. LARGE-EYED FROG. *RANA CHRYSOPRASINA* COPE

REVIEW

OF

TWO SERIES OF AMPHIBIANS*

BY RICHARD DECKERT.

(Color plates from drawings by the author.)

INTRODUCTION.

The species described in these articles belong to the Class Amphibia and the living members can be roughly defined as Vertebrates which undergo an external metamorphosis, hatching from eggs (spawn) as tadpoles or larvae, and gradually assuming the adult form. These larvae have gills at some stage of their development and several species complete the metamorphosis inside the egg and emerge as gillless and tailless frogs.

Most amphibians lose these larval gills, except some of the salamanders, like *Necturus* and *Proteus*, after attaining the adult form. Several of the American land salamanders of the genus *Amblystoma* retain the gills throughout life, if the conditions for developing into the land form are unfavorable, and have been known to breed in this semi-larval state.

The members of the *Amphibia* are divided into three Orders, as follows:

The *Apoda* or limbless amphibians, have a vertebral column with rudimentary ribs and amphicoelous vertebrae sometimes to the number of 300. Each vertebra is cupped before and behind and articulated with the adjoining member by means of a cartilaginous plate. Only one lung is present. The shape of these animals is cylindrical, the head is not distinct from the body, there is no tail and the anus is placed at the posterior end of the body. The body shows no internal rudiments of limbs, is naked and ringed by furrows running around it similar to the segments of an earthworm. A few species have calcareous de-

*The specimens described in these reviews have been preserved and donated to the American Museum of Natural History. Marked with all possible data, they are now available for study

posits in the form of bony scales under the skin. The eye is small, the mouth usually wide, and the teeth large. These animals lead a subterranean life, burrowing in the soil of tropical and subtropical countries. The larvae live in the water until the absorption of the gills. The eggs are round or oval, and are joined together by a gelatinous string. This Order embraces fifty species.

The next order is the *Caudata* or tailed amphibians. These creatures have a spinal column formed of from thirty-seven to ninety-eight vertebrae, which are amphicoelous or opisthocoelous, that is cupped in front and behind or only behind. The skin is naked, the head broad, flat and distinct from the body. All *Caudata* have limbs, although some species only rudimentary ones (*Amphiuma*). Sternal apparatus as well as pelvis always present, although the latter is sometimes rudimentary (*Siren*). All members of this order have a tail throughout life. Lungs are usually present, although the *Plethodontinae* have no lungs; breathing solely through their slimy skin. All salamanders or tailed amphibians hatch from eggs and undergo a metamorphosis from larval to adult form. All of the known species, which number about one hundred and fifty, breathe through gills at some period of their existence.

The last order, *Salientia*, or tailless amphibians, is the one to which all species treated in these articles belong. They are characterized by their form and the presence of four well developed limbs. With all the tail is absent in the adult form.

The skeleton is simple, with comparatively a large and broad skull and a short spinal column, consisting of from five to nine vertebrae and which terminates posteriorly in an elongate pelvis. This peculiar pelvic arrangement is necessary for the attachment of certain muscles that are used in leaping or acting as springs in giving impetus to the enormous leaps, which are possible by most members of this order. Short ribs are present only in one family, (*Discoglossidae*). The limbs are always four in number with four digits on the hand and five on the foot, but in a few species some of the digits are rudimentary or absent (*Stumpffia*). Some tree-toads have a rudiment of a fifth finger on the hand. The skin is either smooth or dry, and more or less

granular or warty, but always naked. In a few species (*Mantophryne, Ceratophrys*) there are calcareous deposits in the skin in the shape of bony plates or granules. The eye is usually large, bright and so very mobile that it can be lowered into the skull until even with the top of the head.

The life habits of frogs and toads present considerable variation. Some species are terrestrial, some arboreal, some aquatic and others subterranean. The food consists of living insects chiefly, but some of the larger species are cannibalistic, and a few of the largest will eat small mammals, birds and snakes.

The order consists of nine families, divided into eleven subfamilies numbering about 1,200 species.

In the descriptions to follow it should be particularly noted that the color patterns are described from *living* subjects throughout. The greater number of the past descriptions of the rarer amphibians are from preserved specimens, and some confusion has resulted owing to the rapid fading of these animals, with a consequent marked change, not only in hue but in *pattern.* The greater number of the colored figures are for the first time sketched from life.

FROGS AND TOADS FROM COSTA RICA.

On May 20, 1914, Mr. Lee S. Crandall, Assistant Curator of Birds at the Zoological Park, and Donald Carter, a student at the Park, returned from a six weeks' collecting trip in Costa Rica. The trip resulted in the capture of many interesting birds and other animals, among the latter being ten species of frogs, toads and tree toads; most of them never before exhibited in this country. Following is a list of the species:

Family BUFONIDAE—Toads.
  Marine Toad, *Bufo marinus,* Seba.

Family HYLIDAE—Tree Toads.
  Baudin's Tree Toad, *Smilisca baudini,* Dum. & Bibr.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.
Underwood's Toad, *Hylodes underwoodi*, Blgr.
Barred Piping Toad, *Hylodes polyptychus*, Cope.
Brown Piping Toad, *Hylodes rhodopis*, Cope.

Family RANIDAE—Frogs.

Subfamily RANINAE—True Frogs.
Large-eyed Frog, *Rana chrysoprasina*, Cope.
Godman's Frog, *Rana godmani*, Gthr.

Subfamily DENDROBATINAE—Harlequin Frogs.
Blue-legged Frog, *Dendrobates typographus*, Keferst.
Scarlet Frog, *Dendrobates typographus ignitus*, Cope.
Ornate Frog, *Dendrobates tinctorius*, Schneider.

Family BUFONIDAE—Toads.

The toads of this family have no teeth in either jaw, the shoulder girdle is arciferous or dilatable, and the vertebrae are procoelous, or cupped in front and without ribs. The tips of the fingers and toes are either obtuse, (genera *Notaden*, *Pseudophryne*, *Nectes*, *Bufo*), pointed, (*Myobatrachus*, *Rhinophrynus*, *Cophophryne*) or triangular, and carrying medium-sized or large adhesive disks or pads, (*Engystomops* and *Nectophryne*). The *Bufonidae* are distributed over all parts of the globe except, of course, the Arctic and Antarctic regions, which have no amphibians. Central America and northern South America have the most genera, as well as the greatest number of species. The species number about one hundred and fifty, grouped in nine genera. Of these genera, *Notaden* (one species) and *Myobatrachus* (one species) are Australian, *Pseudophryne* (four species) is Australian and African, *Nectophryne* (seven species) is African and Indian, *Nectes* (four species) Javan and Sumatran, *Cophophryne* (one species) Indian, *Engystomops* (three species) Central—and South American, *Rhinophrynus* (one species) is Mexican and *Bufo* (about one hundred and thirty species), cosmopolitan with the exception of Madagascar, New Guinea and the Australian region.

The habits of this family are terrestrial except the genus *Nectes,* which is aquatic and has enormous webs on the hind feet. *Nectophryne* is more or less arboreal as indicated by the enormously dilated and padded fingers and toes.

Most of the *Bufonidae* are excellent burrowers, hiding by day and coming forth at dusk to hunt insect prey. Few species, however, are strictly nocturnal, some of the genus Bufo (*Bufo fowleri B. calamita B. quercicus*) having been observed hunting in the brightest sunshine. The genera *Rhinophrynus* of Mexico and *Notaden* and *Myobatrachus* of Australia, are almost exclusively termite and ant-eaters, herein approaching most of the species of the family *Engystomatidae* (the narrow-mouth frogs) whom they also resemble in external appearance, small head, enormously fat body, short arms and legs and comparatively smooth skin.

In their movements the *Bufonidae* are not as agile as the true frogs (*Ranidae*), usually proceeding by short hops, walking, crawling or in rare cases running. They are excellent climbers, taking advantage of every unevenness to obtain a hold, and maintaining their balance in most trying situations. With this they combine great persistence, especially when trying to escape from some pit, well or terrarium. They are but indifferent swimmers and divers with the exception of the genus *Nectes,* and will only enter the water to soak their skin, and during the breeding season for the purpose of depositing their spawn.

All species that have come under observation are great feeders, eating untold numbers of insects, most of which are injurious to plant life. In this they take the place of the insectivorous birds on the ground at night and therefore merit our protection, which unfortunately has been withheld to a great extent until lately. This was probably due to ignorance of their habits, and also to the often unprepossessing appearance of these harmless creatures. The flesh of the larger species is said to be quite as edible as that of some of the true frogs, but is eaten only by a few aboriginal tribes of tropical countries.

In appearance most of the *Bufonidae* are squat, fat and warty. There are, however, some smooth skinned, long legged tropical species that remind one of a true frog.

Marine Toad, *Bufo marinus, Seba.* (*Bufo agua,* Latr., *Bufo ictericus,* Spix., *Bufo horridus,* Daud.) (Boulenger, Cat. Batr. Sal. P. 315).

Color: Brownish or greenish-olive, yellowish or reddish-brown or plain dark brown above with or without large, black, insuliform spots, these usually edged with pale yellow. Sometimes a light median line from behind the head to above the vent. There may be a few scattered whitish spots on the back and sides. Arms and legs sometimes distinctly banded with dark brown. The cranial crests, parotoids and larger warts are usually light, reddish brown. Below this toad is dirty white or yellow with or without brown spots.

Structure: The head is broad and crowned with very prominent bony crests diverging from above the nostrils, edging the canthus rostralis, curving around the orbit above, and sending out and down a branch before and behind the eye, several more or less distinct branches towards the median line above, and one connecting with the enormous parotoid glands. These glands curve down over the arms, and in a toad six and a half inches from snout to vent, attain a length of one and three-quarter inches and a width of one and three-eighth inches. They are studded with large pores. There is a distinct bony ridge along the upper jaw on the edge of the mouth. The tympanum is about one-half the diameter of the eye, and very distinct. The body is covered with large round warts. The skin is loose and much wrinkled and creased. Arms and legs are long and powerful, hands and feet large. The ends of fingers and toes are tipped with dark brown. The toes are moderately webbed. Metatarsal tubercle moderately developed.

Size: Adults range from five inches to eight and one-half inches in length from snout to vent.

Range: Southern Mexico through Central and South America to Southern Argentina. Many of the West Indian Islands.

Thirty-one specimens of the giant marine toad, of all sizes from two to seven inches in length were collected. These large toads are very common throughout their range and no doubt are beneficial in helping to keep the insect life of those regions

FIG 3 MARINE TOAD. *BUFO MARINUS*, SEBA

within reasonable bounds. This is the largest species of the true toads, only exceeded in size by *Rana goliath* and *Rana adspersa,* both African frogs, and possibly *Ceratophrys dorsata* of Brazil. The male can be distinguished from the female by the horny pads on the inner fingers, and by a blackish area on the throat indicating the presence of a large gular pouch. This dark area may be sprinkled with lemon-yellow, especially in young males. The writer has often observed the males sitting with this pouch partly distended in the pan of water provided for their soaking bath in the spacious cage in the lobby of the Reptile House, especially after they had fed well, but so far has not heard their call. The warts on the upper surface of the males are covered with small horny spines, making these toads exceedingly rough to the touch, in contrast to the females, whose warts are round and smooth. When picked up, the male of this species gives voice to a series of harsh squawks similar to those produced by some toy animals. The female is silent, and when handled will shake the whole body as if in a rage, then puff it up enormously but deflating it after a little while with a loud hiss. From the enormous parotoid glands, Dr. J. J. Abel, of Johns-Hopkins University in Baltimore, has recently extracted two distinct and powerful poisons, called respectively *Epinephryn* and *Bufagin.* The latter poison, Dr. Abel has found by experimenting, has many times the strength of *Digitalin,* the "fox-glove" poison, and like this, it affects the heart action. This species has proven one of the hardiest in captivity, seemingly being immune to the festering and bleeding ulcers with which captive toads so often are infested, and to which the majority of them succumb. In the Reptile House these toads are fed on all kinds of insects, and also large earth worms and cockroaches. A few of the largest toads sometimes get an extra tid-bit, such as very young mice or rats.

Although the giant among toads and able to swallow the largest of insects and worms as well as small mammals, this species is not cannibalistic. The writer had repeatedly tried to induce them to eat very young common toads and frogs, which they will snap up but reject immediately. In spite of their enormous size and bulky appearance, the "marine toads" are remarkably agile and quick on their feet. When insects are thrown

into their cage they instantly become alert and with a series of rapid hops, almost cat-like in their stealth, come forth from the darkest corner of their cage where they usually spend the day piled on top of one another and sleeping. Some specimens eventually become so tame that they will take insects and worms from one's hand. The tongue of this toad is very flexible, seemingly more so than in other species. The writer has seen some of the larger specimens snap up a grasshopper or mealworm fully four inches from the toad's head. The species breeds during the rainy season, the eggs being quite small and laid in two strings very similar to those of our own common toads, in puddles, ditches, ponds and canals. The matamorphosis is comparatively rapid, and the baby toads are tiny, measuring scarcely three-eighths of an inch from snout to vent. The call of the male is said to resemble the barking of a dog.

Family HYLIDAE—Tree Toads.

This family is divided into two subfamilies, the *Amphignathodontinae* and the *Hylinae*. It is the latter subfamily only, that we have to deal with in this article. The *Hylinae* or Tree Toads are characterized by the dilatable shoulder girdle, the presence of teeth in the upper jaw, vertebrae cupped in front, absence of ribs, and dilated transverse processes of the sacral vertebra. The end-phalanges of the fingers and toes are claw-shaped and support more or less prominent, adhesive disks. These disks secrete a sticky fluid which, aided by the moist and granular surface of the belly, enable the tree-toads to climb trees, vines and even the glass sides of a terrarium with perfect ease. The skin of the *Hylinae* is always moist and slimy, thus enabling them by means of increased evaporation to withstand greater heat than other amphibians. Tree-toads often can be seen sitting for hours in the most glaring sunlight.

Their skin may be quite smooth or covered with warts of various sizes. In some species of the genera *Hyla, Nototrema, Nictymantis* and all those of *Pternohyla, Corythomantis, Triprion* and *Tetraprion*, the skin of the head adheres to the skull. The *Hylinae* includes some of the brightest colored and most

attractive of all the frogs and toads. All of the species have great powers of color-change. Some of them are really marvellous in this respect. This applies especially to the genus *Hyla*. Most of the *Hylinae* live on the trees, vines, shrubs and other plants, but a few, however, have such tiny adhesive disks that they are of little use, compelling the creatures to live on the ground. All species are insectivorous, although many of the larger ones incline to cannibalism. The family *Hylidae* contains sixteen genera; one of these, *Amphignathodon,* belongs to a separate subfamily. With the latter there are teeth in both jaws. It includes but one species, *A. guentheri,* of Ecuador, and is exceedingly rare.

The other fifteen genera are included in the subfamily *Hylinae.* There are about two hundred and forty known species of which the genus *Hyla* alone has about one hundred and eighty. The pupil of the eye of the toads of this genus is horizontal elliptic. The toes are webbed. Adhesive disks distinct, sometimes very large. The distribution of the *Hylidae* is as follows: The genus *Hyla* is almost cosmopolitan with over thirty species in Australia and Australasia, about one hundred and thirty-five species in Mexico, Central and South America, seven species in the West Indies, ten species in North America, and one species in Europe and Asia. This latter, *Hyla arborea,* has two subspecies in China and Japan. Of the other genera, *Acris,* (one species, two subspecies) and *Chorophilus* (five species) are North American, *Smilisca* (one species) ranges from Texas through Mexico into Northern South America, and the genera *Nototrema* (eight species), *Hylella* (seven species), *Thoropa* (one species), *Phyllomedusa* (fourteen species), *Agalychnis* (four species), *Nictymantis* (two species), *Triprion* (two species), *Tetraprion* (one species), *Diaglena* (one species), *Corythomantis* (one species), and *Pternohyla* (one species) are Central and South American.

This distribution seems to show that the original home of the *Hylidae* was South America. One species of the otherwise North American genus *Chorophilus* occurs in the mountains of Peru (*Ch. cuzcanus*). Quite a number of species of this interesting family are remarkable in their breeding habits. They

do not lay their eggs in ponds, ditches, lakes or swamps as is the habit of most frogs and toads, but use the axillae of large broad-leaved parasitic or other plants for this purpose. One species, *Hyla resinifictrix,* of Brazil, uses knot holes which it lines with the resinous sap of an aromatic tree (*Protium heptaphyllum*) and which soon become filled with rain water. The gigantic *Hyla faber*, also of Brazil, constructs nests or nurseries of mud, forming circular inclosures about twelve inches in diameter in shallow parts of ponds. The eggs are deposited and the tadpoles reared in these nurseries. Other species, (*Hyla goeldi*) and species of the genus *Nototrema* carry the spawn in a pouch on the back until the tadpoles hatch. This pouch is formed by the introverted skin of the back and is possessed by the female only. Species of the genus *Hyla* have the strongest voices of any of the *Salientia.* The call may be a shrill pipe, whistle, a very loud rattle, croak or bark, or a bell-like note (*Hyla gratiosa,* of Florida, *H. faber,* of Brazil) that can be heard in some cases for more than a mile. Each species has its distinctive call and the din produced by these and other toads and frogs in tropical forests during the breeding seasons is said to be ear-splitting.

Baudin's Tree Toad, *Smilisca baudini, Hyla baudini* Dum. & Bibr. (Boulenger Cat. Batr. Sal. P. 371).

Color: The body color is green of varying shades from dark olive through bright pea-green to pale, golden green. A dark band from the eye to the shoulder, covering the tympanum and sometimes extending to the groin, a light spot beneath the eye, and a dark band curving over the upper arm at its insertion. The groin of both sexes is bright yellow, also the throat of the male. Undersides white. These marks are always present. Markings which sometimes disappear with the assumption of pale shades are, a broad band on the middle of the back with two branches extending on the eyelids, two or three cross bars on arms and legs and a few smaller dark spots on the back.

Structure: The head is broad and flat, canthus rostralis acute, eyes large, reddish golden in color and very far apart. The skin is smooth or very finely granular. The legs long, toes

two-thirds webbed, fingers slightly webbed, with adhesive disks smaller than the tympanum. The latter two-thirds the diameter of the eye. The vomerine teeth are situated slightly behind the internal nares, and arranged in a straight series which is interrupted in the middle, thus separating the genus *Smilisca* from *Hyla*. The male has two large gular pouches, one on each side of the throat.

Size: This species is large for a tree toad, reaching a length of three and a half inches from snout to vent. The male is smaller than the female; two and a half inches being the average size.

Range: From southwestern Texas through Mexico to Panama. Four specimens of this fine tree toad were captured near Guapiles, Costa Rica, by Mr. Crandall and his assistant. They were heard calling at night from a piece of waste ground, and their cry was traced to several old tin cans partially filled with water in which the tree toads were sitting. In their cage in the Reptile House they seem to prefer dark corners, where they sleep during the day, coming forth at night and climbing all over the glass sides of their vivarium. They have not been seen feeding since their arrival, although tempted with all kinds of small live insects.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.

This is a most difficult family to define as it approaches the *Bufonidae*, *Hylidae*, *Pelobatidae*, and *Ranidae* in internal as well as in external identification characteristics. Its distribution is South American and Australian almost exclusively. One species (*Liopelma hochstetteri*, the only amphibian there), being found in New Zealand, where it is rare, and four species entering North America.

The family has the following internal structural characteristics: A dilatable shoulder girdle, teeth in the upper jaw only, (subfamily *Cystignathinae*), in both jaws (*Hemiphractinae*), or no teeth at all (*Dendrophryniscinae*). The terminal phalanges or finger and toe ends are never claw-shaped, although some-

times carrying adhesive disks as in the *Hylidae.* The family is composed of three subfamilies, the *Hemiphractinae,* helmet-heads, so called from the shape of their enormous heads which carry large bony protuberances reminding one of the casques or helmets of ancient knights, the *Cystignathinae,* arch-jawed toads, including the greatest number of species, and so called from the enlargement of the lower jaw of some species, and finally the *Dendrophryniscinae,* toads without teeth.

The genera are so numerous and so poorly defined that almost every author gives a different number of the same (Cope, thirty-seven genera, Gadow thirty-two genera, Werner thirty genera, etc.). There are about two hundred and fifty species, of which Australia has about thirty and the remainder are from South America.

Their habits are very diversified, some being burrowers, some strictly aquatic and a great number of species are arboreal, living like tree toads (*Hylidae*) and resembling them in appearance.

Most of the Australian species have a vertical pupil, indicating nocturnal habits.

In size the *Cystignathidae* range from the enormous *Ceratophrys dorsata,* measuring nine inches from snout to vent, and *Leptodactylus pentadactyles,* six to eight inches from snout to vent, to the small *Pseudis minuta,* which measures only three-quarters of an inch from snout to vent. Both extremes in size are found in tropical America. In South America, Central America, Mexico and the West Indies the tree-living species predominate, whereas in Australia the members of this family without exception are burrowers. The largest genus is *Hylodes,* having more than eighty species, *Leptodactylus* has about thirty-five, *Paludicola* has thirty-two and *Ceratophrys* has seventeen species. The other genera have from one to twelve species each.

The breeding habits of this family vary considerably. Some species like *Hylodes martinicensis* carry the tadpoles on their backs while others like some of the *Hylidae* lay the eggs in foamy masses in the axillae of large-leaved plants; but the breeding operations of the majority of the species are unknown The

tadpoles of two species grow to an enormous size; that of *Calyptocephalus gayi,* a giant water frog of Chile, reaches six inches, the adult frog is six to seven inches from snout to vent, while the tadpole of *Pseudis paradoxa,* also a water frog of the Guyanas, is larger still, one specimen being ten and one-third inches long, three and one-third inches of this total is taken up by the body and head, and the tail, which is thick and muscular, measures almost four inches in width by six and two-third inches in length. The size of the larva is all the more remarkable since the adult frog measures only two to two and a half inches from snout to vent.

Underwood's Toad, *Hylodes underwoodi,* Boulenger (Guenther, Biologica Centr. Am.).

Color: The general color is sepia-brown with a W-shaped mark on the shoulders. This mark may be much darker than the ground color or very pale, yellowish brown. The rest of the back is marbled with dark brown, and the arms and legs of some specimens are banded with dark brown. Undersides bluish white, specked with brown.

Structure: The head is long and the snout pointed. The eyes are large with the interorbital space smaller than the eyelid and the skin is rough with large elongated warts, giving this frog some resemblance to our cricket frog. The fingers and toes are free, subarticular tubercles prominent, and the adhesive disks minute, scarcely produced.

Size: From snout to vent the length is one to one and one-quarter inches. The specimens collected were immature and from one-quarter inch to three-quarter inches in length from snout to vent.

Range: Known only from Costa Rica.

Barred Piping Toad, *Hylodes polyptychus,* Cope (Guenther, Biolog. Centr. Am.).

Color: The general color is a dark, brownish olive with a white band between the eyes. The arms and legs are indistinctly

barred, with a rich pink spot on the groin which is hidden when the frog is at rest.

Structure: The skin is finely granulated. The head is broad with the interorbital space equal to or larger than the diameter of the eye. Tympanum small and distinct. Subarticular tubercles distinct. Disks on fingers and toes small, but distinct. Toes not webbed.

Size: The single specimen examined was one and a quarter inches from snout to vent.

Range: Costa Rica.

Brown Piping Toad, *Hylodes rhodopis*, Cope, (Cope Proc. Acad. Phil. 1866).

Color: Brown prevails above, while below it is bluish white with a few scattered brown dots. There is a pale area in front of the eyes on top of the head and the canthus rostralis is margined with dark brown.

Structure: The head is long and pointed and the canthus rostralis acute. The nostrils are close to the top of the snout, the interorbital space is wider than the eye and the tympanum distinct and smaller than the eye. The fingers and toes are equipped with small disks. Subarticular tubercles distinct. The back has several longitudinal rows of warts arranged in the shape of a lyre.

Size: One specimen one and a quarter inches from snout to vent was examined.

Range: Mexico to Costa Rica.

All these small frogs were shy and delicate and did not live long.

Family RANIDAE—Frogs.

The *Ranidae* belong to the second group of tailless amphibians, the *Firmisternia*, so-called because the halves of the shoulder girdle are united below, forming a firm median bar or *metasternum*, instead of overlapping as in the *Arcifera*, to which

all previously described frogs and toads belong. The vertebrae are cupped in front.

The *Ranidae* are divided into the following subfamilies according to the arrangements or absence of teeth:

Subfamily *Ceratobatrachinae,* having teeth in both jaws and consisting of only one genus and species, *Ceratobatrachus guentheri,* of the Solomon Islands. This is a large, huge-headed land frog with horn-like appendages on the eyelids, snout, sides of body and limbs.

Subfamily *Raninae* or true frogs with teeth in the upper jaw only. This is the most numerous branch of the family, comprising about forty genera with some three hundred and seventy species. These are so diverse in identification characteristics and habits that it would be impossible to describe all the genera in this paper, and but a few examples will be mentioned here.

Genus *Polypedatus* (*Rhacophorus*), frogs resembling tree toads in having the tips of the fingers and toes with adhesive disks, but the end phalanges not claw-shaped as in the *Hylidae.* Some species of this large genus have enormous webs between the fingers as well as the toes. They have been called flying frogs but do not actually fly, only jumping from great heights occasionally and using the large expanse of web as a parachute. Fifty-four species are known from southern and eastern Asia, and sixteen from Madagascar. Many species of this genus lay their eggs between leaves glued together by the female to form a sort of funnel which they suspend over a ditch, pond or brook, so that when the tadpoles have hatched they will drop into the water below their nest. This queer mode of depositing eggs is also practiced by the African genus *Chiromantis,* which resembles *Polypedates,* except that it has no web between the fingers and that the two inner fingers are opposed to the outer ones, enabling these frogs to grasp twigs and stems in climbing. Their movements are slow and mechanical, like those of the African and Madagascan cameleons. "Cameleon frogs" would therefore be an appropriate popular name for these queer creatures.

Hylambates with about twenty species, all African, is also a tree frog in the true sense. Our own so-called tree frogs are

really tree toads, being grouped with the toads in the superfamily *Arcifera.*

The genus *Hylambates* has some highly colored frogs with odd and picturesque color patterns. The female of one species (*H. brevirostris*) has been found by Boulenger to have a singular habit of nursing, carrying the eggs about in her mouth. The African and Madagascan genus *Rappia* is also very numerous, having about thirty known species. They are mostly small tree-living frogs with rather short, stout limbs, all beautifully colored and have great powers of color-change.

The female of one species from Madagascar has the singular habit of winding the eggs, which resemble a string of beads, around her forelegs.

Trichobatrachus, only one species of which is known so far, is peculiar in the possession of hair-like papillae forming a thick fringe on each side of the flank, also on the upper side of the thighs. This frog inhabits Central Africa.

Phyllobates, having five species, all small frogs, is a South American genus. The tadpoles of *Ph. trinitatis* of Trinidad, British West Indies, adhere to the back of the male by means of their suckers, and are thus carried from evaporating pools to more permanent ones. *Arthroleptis* comprises twenty species, mostly African. One species, *A. seychellensis,* of the Seychelle Islands, was found on some tree ferns carrying its tadpoles in the same manner as the genus described before, with the exception that the larvae adhered to the back of the adult by means of a sticky secretion.

Rana, the type genus of the whole family, is also the largest, having about one hundred and fifty species, of which fifteen inhabit the United States.

The Indian region including most of the islands of the Indian and Pacific Oceans, has the greater number of species, Africa has but a slightly smaller number.

The structural description of the genus is as follows: The pupil of the eye is horizontal and the tongue deeply notched and free behind. Teeth on the upper jaw and on the vomers, (small

protuberances in the upper jaw), between or slightly behind the internal nares or nostrils. The fingers are free and the toes are more or less webbed. The fourth and fifth metatarsal bones of the central part of the foot diverge, but are united by the web. The terminal phalanges may be simple and pointed or T-shaped, sometimes carrying disks. The external ear plate (tympanum) is usually distinct. The males of most species have vocal sacs, which may be internal (*Rana catesbiana, R. sylvatica, R. temporaria*), or external, protruding through slits under the angle of the lower jaw or over the arm insertion when they are distended in calling (*R. esculenta, R. aesopus, R. tigerina*).

Nuptial excrescences in the shape of horny or spiny pads, spikes or granules may be found on the forelimbs and hands of the males of many species, reaching their greatest development in *Rana liebigii* of the Himalayan region, India.

The males of this genus are further distinguished by their heavy forelimbs or arms which in the aforementioned species are enormously developed. Gadow says in his "Amphibia and Reptiles" (Cambr. Nat. Hist.): "All species of *Rana* spawn in the water. except those of the Solomon Islands, where the only permanent bodies of water are roaring mountain torrents unsuitable for the metamorphosis of amphibian larvae."

One species from this group of Islands, *Rana opisthodon,* lays its eggs in moist crevices in rocks near the water. The larvae undergo the whole metamorphosis from tadpole to frog inside the eggs and emerge as perfect frogs, absolutely tailless. The tip of the snout of the young frog is armed with a short, horny protuberance which is used to perforate the egg and is absorbed soon after the animal has emerged. The largest species of all frog-like amphibians is *Rana goliath* of the Cameroons, attaining a length of twelve inches from snout to vent. Next in size are *Rana adspersa* (nine and one-quarter inches), of South and Central Africa, *Rana macrodon* (nine inches) of India. and Malaysia, *Rana catesbiana* (six to eight inches) of North America, *Rana tigerina* (six to seven inches) of India and Malaysia, and *Rana guppyi* (six to seven inches) of the Solomon Islands. All these large species are cannibalistic and large examples of our own bull frog have been known to swallow half-

grown rats, small chicks, ducklings, sparrows, toads and young snakes.

Insects, of course, make up the greater percentage of the food.

Some species of this genus are quite terrestrial, only entering the water during the breeding season, while others are typical water frogs never wandering far from their native stream, pool or swamp.

The genus *Gampsosteonyx* resembles an ordinary frog, but has vertical pupils. The terminal points of the fingers end in sharp, bony claws which perforate the skin of the finger tips. One species is known: *G. batesi* from the French Congo.

Subfamily DENDROBATINAE—Harlequin Frogs.

These small frogs are separated from the others of the family by the absence of teeth from both jaws and comprise three genera: *Dendrobates*, of Tropical America, *Mantella*, of Madagascar and *Cardioglossa* with one species *C. gracilis* of the French Congo. The frogs of the genera *Mantella* and *Dendrobates* are very much alike in shape, size and in possession of a striking color pattern. Deep black, bright blues, brilliant reds, greens and yellows in many contrasting combinations are the colors which often form fantastic patterns.

The tiniest insects are the food of these little harlequins of the frogs' world and they are usually found near fallen decaying tree trunks, where they feed on small termites, or in banana plantations, where they can be seen in numbers about the fallen and decaying fruit which attracts myriads of small fruit flies.

Dendrobates has seventeen species, *Mantella* nine species and *Cardioglossa* has one.

Subfamily RANINAE—True Frogs.

Large Eyed Frog, *Rana chrysoprasina*, Cope (Boulenger, Cat. Batr. Sal. P. 49).

Color: The head is green and the back, sides and limbs a yellowish olive with a few brown specks. A dark line extends

from the tip of the snout through the nostril and eye over the tympanum and below the lateral glandular fold to the groin. The edge of the upper jaw has a few small brown spots, the eye is brassy yellow and the sides and belly an immaculate golden yellow.

Structure: The head is broad, flat, snout acuminate, projecting beyond the mouth and the tympanum two-thirds the diameter of the eye, which is very large. The tips of the fingers and toes are slightly dilated, fingers very long and slender, and the toes webbed four-fifths of their length. The skin is very finely pustulated above and smooth underneath. There is a lateral fold on each side of the body and narrow longitudinal glandular ridges on the calf of the leg.

Size: The specimen examined was three and one-quarter inches from snout to vent.

Range: Costa Rica.

One adult, one young frog and several tadpoles of this beautiful species were collected near Guapiles. This frog is very shy, as most large-eyed frogs usually are, and seeks cover with great rapidity when disturbed. Like most water frogs it is a good feeder, and so far has proven a very satisfactory captive. When taken up it will sit quietly in the open hand and will not jump unless frightened by a quick movement. Several of the tadpoles have metamorphosed and are living now as young frogs in a vivarium with small tree toads on the main floor of the Reptile House. In the daytime they usually sit concealed under some moss, but come forth with the darkness and occupy the pan of water provided for them.

Godman's Frog, *Rana godmani*, Guenther (Biologia Centr. Am.).

Color: The color is greenish olive above with indistinct darker spots and whitish below.

Structure: The structure is like that of *Rana clamitans*, but with much shorter legs.

Size: One young specimen metamorphosed from a tadpole is in the Reptile House. This frog is just as shy as the preceding species, constantly hiding under a large, flat stone in its terrarium. The size of the adult is from two and one-half to three and one-half inches.

Range: Costa Rica.

Subfamily DENDROBATINAE—Harlequin Frogs.

Blue Legged Frog, *Dendrobates typographus*, Keferstein (Boulenger, Cat. Batr. Sal. P. 143).

Color: This frog is a brilliant red above and below with or without tiny black dots. The legs and forearms are brilliant dark blue or blue-black, and on the upper side of the thighs there is a row of small red dots. The blue of the inner arm extends across the breast.

Structure: The snout is obtuse and the canthus rostralis rounded. The tympanum is distinct but small, measuring about one-half of the diameter of the eye, and the interorbital space twice the width of the eye. The arms and legs are slender and moderately long with disks on the fingers and toes equal to or exceeding the tympanum in size. The skin is smooth and shiny.

Size: Adult frogs are one inch or less from snout to vent.

Range: Costa Rica. Eight of these queer little frogs were collected by Mr. Crandall. They were found prowling along the decaying timbers of a fallen fence, probably hunting for the small white termites that usually infest such places.

Scarlet Frog, *Dendrobates typographus*, subspecies *ignitus*, Cope (Proc. Acad. Phil. 1874).

Color: As the name implies, it is brilliant red all over except for a small star-shaped area on the breast and a larger one at the junction of the hind legs and the belly, beneath which is dark blue.

Structure: Exactly like *D. typographus* var. typica.

Range: Costa Rica. Rarer than the typical form. One specimen from Limon.

Ornate Frog, *Dendrobates tinctorius*, Schneider, (Boulenger Cat. Batr. Sal. P. 142).

Color: The color is very variable, the single specimen collected by Mr. Crandall was bright emerald green and black; the green predominating above and the black below.

Structure: The snout is truncate and the canthus rostralis rounded. The interorbital space is wider than the diameter of the eye and the tympanum one-half the diameter of the eye. The arms and legs are slender, with the disks of the fingers and toes distinct. The skin is smooth and shiny. The male has a subgular vocal sac.

Size: From snout to vent it is one to one and one-half inches in length.

Range: Tropical America. This specimen has proven the hardiest of the smaller frogs brought from Costa Rica and lives on tiny fruit flies that are enticed into its terrarium with slices of banana, apple or pieces of wet bread. It can see a fly at quite some distance, and with short hops follows every turn of its flight until it alights within reach, when it is greedily snapped up. The tongue, which is not notched behind like that of the frogs of the genus *Rana*, can be thrust out for quite some distance. This curious little creature does not always hop, but will often elevate its body on its long slender legs and stalk around as though walking on stilts. The adhesive disks, although tiny, are large enough to enable this little frog to climb up the glass sides of its terrarium. Owing to their intensely bright coloration, Mr. Ditmars has suggested the very appropriate name of Harlequin Frogs for these odd creatures.

The frogs of the genus *Dendrobates* are known for the intensely virile poison contained in their skin secretion. This poison, especially that of *D. tinctorius*, has been put to several

uses by the aborigines, one being that of an arrow poison, and another a bleaching agent, which turns the green of parrots' feathers to yellow. The poison, like that of the toads, has no power to injure by touch, acting only when injected into the circulation or rubbed into a deep wound. The life habits of these queer little creatures are also worthy of note, especially the nursing or carrying about of the tadpoles. These habits are shared by the frogs of the *Ranoid* genus *Prostherapis* and *Arthroleptis,* and by species of *Hylodes* of the *Cystignathidae.* As has been observed by the naturalists J. Natterer, H. S. Smith and A. Kappler, frogs of this genus will take their tadpoles upon their backs and carry them to another pool in times of drought. A. Kappler saw *D. tinctorius* and *D. trivittatus* in Surinam go into evaporating pools, sit still awhile and then emerge with tadpoles, some frogs carrying from twelve to eighteen, which adhered to their backs by means of a sticky secretion. Whether this secretion is exuded by the frog or the tadpole is not known as yet, nor has the sex of the nurse been determined up to the present writing.

Since the arrival of this collection additional material has been promised us by several gentlemen who have been to the canal zone and who, upon being shown the specimens, said that they were fairly abundant in those regions. Other interesting frogs, toads and tree toads have also been promised us from that region, and it is hoped that the writer will be enabled to make further observations on these interesting and little-known creatures. Much work is yet to be done in this line of investigation, and a large field is open for the student having the opportunity to observe these creatures in their natural environments.

FIG 4 AUSTRALIAN FROGS

FROGS AND TOADS FROM NEW SOUTH WALES.*

The Australian frogs and toads that are described in this paper will be of especial interest, since it is the first time that these important species have been exhibited in the Reptile House (alive) or the United States. Among them are included the following species:

Family BUFONIDAE—Toads.
Australian Toad, *Pseudophryne australis,* Gray.

Family HYLIDAE—Tree Toads.
Perron's Tree Toad, *Hyla perronii,* Bibron.
Golden Tree Toad, *Hyla aurea,* Lesson.
White's Tree Toad, *Hyla coerulea,* White.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.
Sand "Frog," *Limnodynastes dorsalis,* Gray.
Silver "Frog," *Heleioporus pictus,* Peters.

Family BUFONIDAE—Toads.
Australian Toad, *Pseudophryne australis,* Gray. (Boulenger Cat. Batr. Sal. P. 277).

Color: Above, the body is blackish brown with a yellow or reddish narrow streak on the posterior back. The posterior sides of the arms are bright orange-yellow and the rear sides of the thighs usually have a few yellow spots. The throat, abdomen and under surface of the arms and legs are marbled black and white.

Structure: The head is rounded; canthus rostralis not produced. The interorbital space is as wide as the eyelid. The fingers and toes are short without web or dilatations. The skin is smooth or with a few indistinct flat warts. With the male there is an internal gular vocal sac, and an oval flat gland on the hinder side of each thigh. The pupil of the eye is horizontal.

*A resumé of the Families embraced in this article will be found in the preceding pages.

Size: One and one-quarter inches, snout to vent.

Range: Australia. The two specimens examined were from near Sydney, N. S. W. This little toad is said to be quite common all over Australia in localities favorable for amphibian life, and is interesting on account of its breeding habits. The large eggs are laid in damp places in numbers up to ninety under stones, stumps and other hiding places, and have been found in November, January and May near Sydney. Oviposition takes place after heavy rains and the next rain is depended upon to set the larvae free.

This may occur within two or three weeks, or three or four months. The embryo is very tenacious of life and, as noted above, will accommodate itself to remaining in the jelly-like mass of the egg for a long time. The actual limit for this has not yet been determined; four months being the longest time recorded. The two specimens now in our collection seem to be hardy, and live in company with *Hyla pickeringii* and *Dendrobates tinctorius* in a small terrarium, the bottom of which is covered with very damp wood-pulp.

They feed greedily on all kinds of small insects; the method of hunting differing from that of any frog or toad observed by the writer. Instead of hopping they slowly and deliberately creep up to their intended prey, moving each arm and leg separately, first an arm, then the leg of the opposite side, then the other arm and lastly the other leg, giving the whole movement a singular mechanical appearance. When about a half-inch from the insect, the tongue shoots forth with lightning-like speed and the insect vanishes. The toad retains its seemingly strained position until another victim is sighted, when the whole manœuvre is repeated. When disturbed, however, these toads hop in ordinary fashion.

Family HYLIDAE—Tree Toads.

Perron's Tree Toad, *Hyla perronii,* Bibron (Boulenger Cat. Batr. Sal. P. 390).

Color: Brown above, but subject to great variation and color-change. There may be a distinct pattern of dark marblings

or dots, but when the animal is at rest, it is usually dark brown, without dark spots, though with bright yellow dots, which are lined with black and intermingled with emerald green spots slightly larger than the head of a pin. The abdomen is white, throat (male) marbled with brown, and the arm-insertion (behind), the groin and the concealed surface of thigh, calf and foot are bright orange, marbled with black. These colors are not seen when the frog is at rest. The eye is silver with the pupil contracted to a tiny square with four black lines radiating from it and dividing the eye into quarters. When active the color fades until the whole frog is pale reddish or yellowish brown and the arms and legs barred with darker brown. The color of the eye also changes, becoming bright yellow as the pupil expands into a regular, horizontal oval.

Structure: The head is broader than long, snout rounded and canthus rostralis rounded. Loreal region slightly concave. Interorbital space equal in width of the diameter of the eye. Tympanum distinct and two-thirds the diameter of the eye. The fingers are half webbed and the toes about three-fourths webbed, with large adhesive disks about half the diameter of the eye. The upper surface is sometimes smooth and occasionally covered with small roundish warts. A fold of skin extends from the eye over the tympanum to the shoulder, and another fold across the breast. The male has a large subgular vocal sac. The entire lower surfaces are granulated.

Size: It attains a length of two and a half inches from snout to vent.

Range: Northern and Eastern Australia and Tasmania.

One specimen from near Sydney, New South Wales, is in the collection of the Reptile House. It usually sits in a corner and near the top of its vivarium, with the pupils contracted, apparently sound asleep. At dusk it becomes active, climbing slowly over the glass sides of the case until it spies an insect, when it is capable of making enormous leaps. It does not seem particularly shy, and will allow itself to be handled, clinging to one's fingers with its sticky toes. When the plants in the Reptile House are being syringed in the morning and evening, the sound of the splashing water stimulates this tree-toad to giving voice to its

loud call. This call resembles the noise of the pneumatic drill used by structural iron workers, and might be described as a loud, metallic rattling. The throat pouch is expanded into a large globe, larger than the tree-toad's head, while the entire body vibrates with the force of the exertion used in producing the call.

Golden Toad, Golden "Frog," *Hyla aurea,* Lesson (Boulenger Cat. Batr. Sal. P. 410).

Color: The general body color is a bright metallic green, sometimes bluish, sometimes yellow in tone. From the tip of the snout through the nostrils, over the eyes and tympanum to the groin, extends a wide brown band, and on the back there are usually a series of spots of varying size and shape, but of the same color, which sometimes fuse into longitudinal bands. A brown band, which becomes yellow or silver, passes from the tip of the snout along the upper margin of the mouth and ends at the shoulder. From the nostril through the eye, interrupted by the tympanum, is a black streak which ends behind the shoulder. The arms and legs are brown, the former spotted, and the latter longitudinally banded with green. All of the brown spots and bars may become beautifully golden or coppery bronze, and the glandular, lateral fold a pale, golden color. The color at the groin is deep blue-black. The sides are green, sometimes with a bronze shading, the tympanum bronze and the under sides pure, silvery white. The entire toad is subject to strong color changes, sometimes becoming plain blue-black with metallic reflections. The eye is large, brilliant and of a beautiful, reddish-gold color.

Structure: In general form it is like a *Rana*. The head is a little longer than broad, the interorbital space narrower than the eyelid, tympanum about half the diameter of the eye, canthus rostralis distinct and the loreal region concave. The fingers are free and the toes almost entirely webbed. The disks of the fingers and toes are small. The skin may be entirely smooth or warty above. A longitudinal fold extends from the eye to the groin. The male has two internal vocal sacs.

Size: It attains a size of two and a half to three and a half inches from snout to vent.

FIG. 5. GOLDEN TREE TOAD, *HYLA AUREA*, LESS.

FIG. 6. WHITE'S TREE TOAD, *HYLA COERULEA*, WHITE

Range: The Golden Tree Toad is found throughout Australia and some of the Australian Islands.

This is one of the commonest of Australian toads and is called "bell frog" in its native country. In shape, habits and actions it is absolutely different from any other species of the genus *Hyla*, so much so that other naturalists have made it the type of a distinct genus, *Ranoidea*, Tschudi. But the internal structure is that of a typical *Hyla* and Boulenger in his admirable "Catalogue of Batrachia Salientia," has included it among the *Hyla*, where it rightly belongs. It is a large, gorgeously colored species and reminds one of a water frog in appearance as well as in habits. In its terrarium in the Reptile House it will sit for hours on the ground or in the pan of water provided, never attempting to climb up the sides of its cage like its cage-mates. It is also like the water frogs, distinctly cannibalistic, seemingly preferring small frogs to any other food. It is a greedy feeder and will eat all kinds of insects. After sundown its call can be heard in the Reptile House. This call is a long, drawn-out and loud croak, very coarse but sometimes ending in a bell-like note, "bong"; also very loud. The species is quite hardy and can endure considerable cold. At a low temperature it loses its beautiful tints and assumes a plain blackish-olive or blue-black color. It is most beautiful and active at a temperature of about 70 degrees F. When taken up it will struggle violently, and upon being released, hop away in a series of rapidly executed, enormously long leaps, reminding one of a water frog. Its eggs are laid in a white, frothy mass in pools, canals, wells or other permanent bodies of water, differing herein from most Australian frogs. Oviposition takes place during August and September. If these months should be dry, however, the species waits until the following spring. In its native country this species frequents permanent bodies of quiet water, never climbing on the bushes and trees surrounding such places, but always remaining at the water's margin, plunging into the protecting element at the slightest alarm, like a true water frog. The "golden frog" is hunted at night by the Australian natives (Bushmen), with the aid of lanterns and torches. Numbers of them are spitted upon a sharp stick as they are caught, roasted over an open fire,

and eaten with great relish by the natives, without taking the trouble to remove the viscera.

White's Tree Toad, *Hyla coerulea,* White (Boulenger Cat. Sal. P. 383).

Color: The general color of the body is a bright, leaf-green to dark olive above; undersides pinkish-white, and the concealed surfaces of the thighs and arms, fleshy-pink. A few round or elongate white spots are sometimes present on the sides, limbs and back.

Structure: The head is large, broad and flat, with rounded and truncate snout, canthus rostralis distinct, loreal region concave and the interorbital space much wider than the diameter of the eyelid. A strong fold extends over the tympanum, which is from two-thirds to four-fifths the diameter of the eye, to above the arm insertion. The hands are large, fingers are webbed one-third and the toes almost entirely webbed. The adhesive disks are very large, those of the hands equal in diameter to the tympanum, those of the feet smaller. There is a tarsal fold, and the subarticular tubercle is prominent. The skin is smooth and shiny, much thickened on the head and scapular region, studded with large pores, and the under surfaces are granulate. The male has a large gular vocal sac.

Size: This species is one of the largest of the *Hylidae,* attaining a length of five inches; our largest specimen measuring four inches from snout to vent.

Range: Australia, Tasmania, Australasia, Malaysia. The nine specimens exhibited in the Reptile House are from New South Wales. This large and fine species is a typical *Hyla* in appearance as well as in habits. In its coloration, it is one of the most constant of all *Hylas,* resembling in this respect our own *Hyla cinerea, s. carolinensis.* The upper sides are always some shade of green. The iris is a beautiful, golden bronze when the frog is awake, and when asleep may be pale, silvery-blue. In the Reptile House it shares its terrarium with *Hyla aurea.* Unlike the latter, it is tame and confiding, and when picked up will

cling to the hand, climb around it looking for a comfortable spot to sit, and upon finding one will settle down, tucking its hands and feet well under. A German naturalist named Riedel relates the following amusing incident, illustrating well the phlegmatic disposition of this tree-toad: He had taken a specimen to show a friend, placing it on the cover of a large beer-stein, such as are in general use in Germany. Whenever the owner lifted the stein and tipped the cover back to take a drink, he turned the tree-toad upside down in doing so. The latter did not jump, but clung to the cover with its enormous hands, and when the cover was placed in its natural position it immediately settled down in its former position, tucking its hands and feet under its body, always a sign of contentment. It remained thus on the cover of the stein for over half an hour, being frequently disturbed by the drinking operations of the owner.

This toad has the sense of locality very much developed, returning again and again to the same spot for basking or sleeping. In this it resembles our *Hyla versicolor*. On cold nights when all the other tree-toads in the collections creep under cover, these big fellows will be seen sitting motionless in their accustomed places. It will also sit for hours in the brightest sunlight, apparently as indifferent to the burning heat as it is to the cold. The voracity of this species is in keeping with its size. Anything is welcome from mice and small frogs to all kinds of insects, worms and small crustaceans. It will eat until abnormally gorged. In cleaning the vivarium, I had occasion to put these large tree-toads temporarily in another vivarium containing *Hyla arborea*, *Bufo calamita* and *Rana temporaria*. The big fellows were hardly placed in this cage when they attempted to capture and eat the smaller amphibians, and if they had been left to their own devices, would soon have swallowed all the rightful inhabitants. The call of the male can be heard in the Reptile House usually late in the afternoon, and consists of the syllables "*kra-kra-kra-kra*," repeated about twenty times. At first it is not loud, but gains in volume as the cry proceeds, until near the end it resembles the barking of a large dog. The enormous finger disks give this frog unusual clinging powers, and when one is lifted from its place, it will usually grasp any object near and hold on with such strength and tenacity that great care must be

exercised not to injure the animal in trying to loosen its hold. *Hyla coerulea* breeds in permanent bodies of water such as cisterns, wells, reservoirs and canals. The spawn, like that of *H. aurea,* is laid in the water in large clumps and enveloped in a foamy mass that floats on the surface. In its native land, this species is found in numbers under the roofs of outhouses, verandas, and other places of concealment; sometimes coming into the dwelling houses at night, attracted by the light of lamps and by the presence of insects. When there is rain, the frogs around a house will set up a deafening din, almost driving the occupants to distraction. The species should be useful as an insect-destroyer on account of its size and proportionate voracity. The geographical distribution of this tree-toad is very extensive, ranging throughout most of the islands of the Pacific and even some of the Indian Ocean, this being probably due to the ease with which the frog can be carried from place to place in cargoes of lumber or fruit. The phlegmatic habits of this species, no doubt, also favor such distribution.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.

Sand "Frog," *Limnodynastes dorsalis,* Gray (Boulenger Cat. Batr. Sal. P. 261).

Color: The color is variable, usually an olive brown, with or without spots. Our specimen is blue-black above with a few inky black spots on the sides and posterior back. A broad, yellow streak extends from in front of the eye to the commissure of the mouth, and a series of broad yellow spots, which in some specimens is blended into a band, from behind the tympanum to the groin. A second series of yellow blotches occurs below this, and a number of greenish-yellow spots on the upper eyelids and back and a narrow yellow streak on the coccygeal region. The outer edge of the tarsus and outer toe are yellow, and the rest of the foot bluish white. There are some yellow spots on the arms, belly white, and the throat yellow. The eye of both sexes is bright, golden-yellow.

Structure: The head is large and the snout rounded. The mouth is very wide, eyes large, very prominent and brilliant in

coloring, pupil vertical and the interorbital space equal to the width of the upper eyelid. The tympanum is distinct and two-thirds of the size of the diameter of the eye; skin smooth above and below; arms and legs short, and the fingers and toes slender. Subarticular tubercles prominent. A cuneiform shovel on the tarsus. A parotid-like swelling on the calf (male only). The male has a subgular vocal sac. There is an elongate, yellow gland extending from beneath the eye to above the arm-insertion (see color description).

Size: Our specimen measures two inches from snout to vent.

Range: Australia.

This odd creature has a startling resemblance to our spade-foot toads, *Scaphiopus*, of the family *Pelobatidae*, in habits, coloring and structure. In Australia it occurs in sandy regions which are dry the greater part of the year—in fact, without permanent bodies of water, and is therefore compelled to await the occasional heavy rains for the consummation of its breeding operations. This is likely to happen almost any time of the year. The spawn is laid in frothy clumps in the temporary pools formed by these rains, and the metamorphosis is correspondingly rapid, exactly as in our *Scaphiopus*. In *Scaphiopus*, however, the eggs are laid in strings. The species is fairly common on the south coast and is called "sand frog" by the farmers. It is sometimes dug up in the gardens. Its habits are nocturnal as indicated by the vertical pupil, and it feeds chiefly on the large spiders that abound on the ground at night. In the Reptile House this frog is kept in a small terrarium in company with the Silver Frog and seems fairly hardy. It is a good feeder with cannibalistic tendencies. By day it lies buried in the fine gravel, but at night comes forth, sitting partly buried, alert for any insect that may come its way. It progresses by short hops of startling rapidity.

Silver "Frog," *Heleioporus pictus*, Peters (Boulenger Cat. Batr. Sal. P. 272).

Color: The body is yellowish or grayish olive with large black, brown or green spots. There is sometimes a pale yellowish

vertebral line. A long, white gland extends from beneath the eye to the shoulder, and a black streak from the nostril through the eye to above the shoulder. The belly is white, and the throat (male) yellow. The arms and legs barred with the same color as the large spots on the back, and the eye is a pale, brassy yellow.

Structure: The head is moderately large and the snout rounded. Eyes close together; fingers and toes short; subarticular tubercles well developed and metatarsal tubercle large. Arms and legs short; tympanum indistinct; skin smooth and the toes very slightly webbed.

Size: Adult males one and a half to one and three-quarter inches from snout to vent.

Range: Australia (Victoria and New South Wales).

This species is not nearly so nocturnal as the preceding, and is always ready to feed on insects placed in its terrarium. In New South Wales it is called "silver frog" and seems fairly common around Sydney. Its eggs are laid in pools formed by the heavy rains and the metamorphosis is rapid, keeping pace with the evaporation of the water in the temporary pools. This species does not seem to be possessed of great powers of color-change, the specimens living in the Reptile House keeping the same dress under various conditions, which would induce other frogs, at least, to change from light to dark or vice versa. The call is a rattling croak which is not very loud, the throat pouch being inflated to the size of a small marble during the call. The "silver frog" is rather shy, squatting low in its vivarium upon being approached, and when further disturbed will dart about in great haste, seeking concealment. It is a ready feeder, however, and we hope to be able to keep it alive for some time to come.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBER 2.

A TETRAPTERYX STAGE IN THE ANCESTRY OF BIRDS

By

C. William Beebe,
CURATOR OF BIRDS

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

November, 1915

FIG 7 TETRAPTERYX STAGE IN THE ANCESTRY OF BIRDS
The drawing is based on characters present in Archaeopteryx, and in the young of living birds

A TETRAPTERYX STAGE IN THE ANCESTRY OF BIRDS

By C. William Beebe,
Curator of Birds.

I. Introduction.

II. Pelvic Wing:
    White-winged Dove.
    Domestic Pigeons.
    Jacana.
    Great Horned Owl.
    Archaeopteryx.

III. Argument.

Part I.— Introduction.

Our knowledge of the genealogy of birds is in inverse ratio to the abundance of these organisms on the earth today. We know of quite primitive forms of fish—both fossil and living—of reptiles and of mammals. But of living birds, those which show encouragingly primitive characters exhibit also an equal number of extremely specialized ones.

Some six or seven million years ago in the Cretaceous Period we know that there lived creatures which undeniably deserve the name of birds. Ichthyornis was a strong-flying, tern-like type with numerous, recurved teeth, and Hesperornis was also toothed, but practically wingless, essentially a diving bird, and on shore probably more helpless than a seal.

In the Jurassic, let us say four million years earlier, two more or less complete fossil skeletons have been discovered, and an odd feather or two of the famous Archaeopteryx, the *sine qua non* of avian genealogy. Teeth again we find in a very lizard-like head; delicate, weak, wing bones supporting a good-sized but rounded wing, and the fore limb terminating in three well devel-

oped, clawed fingers; a long, vertebrated tail, with a pair of excellent feathers sprouting at each joint and a pair of feet admirably adapted for perching. The unmistakably reptilian traces give weight to Huxley's superclass Sauropsida.

Slight though this evidence is compared to the imposing array of fossil reptiles and mammals, it nevertheless provides an unmistakable lead in the direction of small, arboreal, lizard-like creatures along a still earlier line of ancestry.

I do not wish in this paper to discuss, except in one respect, the various characters of Archaeopteryx. I am working out a life-sized restoration of a flock of seven of these winged creatures of ancient times and not until this is completed shall I feel confident of expressing any new views on the general character of this much discussed creature.

My present thesis, while in a way independent of Archaeopteryx, yet is given force in dynamic presentation by consideration of this strange creature.

Perhaps the most astounding thing about this being is the perfection of its wing and tail feathers. Without going into reasons, I am convinced that Archaeopteryx was a bird of very limited powers of flight. I am not certain that it could flap at all and if it could, its aerial feats hardly equalled those of a modern tinamou or domestic fowl. It certainly had very excellent powers of scaling, and in this direction probably exceeded any modern flying squirrel or lemur.

Whether this be conceded or not is aside from my point, which is concerning the origin of this wing. Our knowledge of the workings of evolution often enable us to visualize the growth and later development of an organ, its subsequent specialization and perhaps ultimate degeneration, while we utterly fail to explain its origin or early development. It is well within the limits of gradual cumulative variation to admit the change from an Archaeopteryx to a modern wing. The wing bones increase in size and those of the hand coalesce, the fingers become mittened in flesh and tendon; the primaries increase in number creeping out upon the phalanges, and the muscles wax stronger, become

larger and find adequate place for attachment upon a greatly enlarged sternum. But how could the wing have reached its Archaeopteryx stage of development?

In Mexican or Neotropical jungles bordering rivers and streams it is a common sight to see great iguanas resting high among the upper branches and foliage. When suddenly alarmed or toward sunset, these great reptiles do not bother to climb slowly down along their back trails which they so laboriously mounted earlier in the day. They recklessly launch out into mid-air and with legs widely extended, body flattened, toes clutching at the empty air, they hurtle downward, landing with a crash into the underbrush or with a splash in the water. Perhaps their flattening may help somewhat to break their fall, but I doubt if this would save their life were they to land upon hard ground. Twice, in fact, I have seen iguanas after a bad take off, half turn in the air, so that they landed in the water on their side or in one case actually upside down, when the reptile seemed stunned for a minute before it turned over and swam from sight. Here, it seems to me, we have a very probable *anlage* of scaling flight, as ultimately perfected in Archaeopteryx.

But if we arm our imaginations with a prejurassic, parachuting lizard on the one hand, and Archaeopteryx on the other, we still have a hiatus which no logical combining of proportional characters will bridge. Suppose if you will that the scales along the posterior edge of the fore leg and those along the tail begin to lengthen. Carry these along to a fair development and then start the hopeful organism out into mid-air and it will prove an utter failure. The scaly primaries may be sufficient to support the front part of the body, but the tail scales would certainly not suffice both to balance and to bear up the remainder of the lizard. The result would be a woeful sagging which must bring instant disaster,—a herpetological Darius Green which could not hope to leave offspring to work out their fossil destiny. The development of scaling flight with nothing to correspond to the great lateral and caudal membranes of flying mammals is inconceivable. Something is needed to bridge over the very beginnings of the parachuting wing function. Even a flying fish has two nodes of aerial support during its brief essay into a thinner

medium. It spreads capable little planes aft as well as forward. Cut off the pelvic fins and I imagine it would plop hindmost into the water almost as soon as it emerged. Some such accessory has always seemed to me necessary if we are to complete our lizard-to-Archaeopteryx line of ascent.

Recently, while examining the fresh body of a four-days'-old White-winged Dove in the New York Zoological Park, I observed on its almost naked body a remarkable development of sprouting quills across the upper part of the hind-leg, and extending toward the tail across the patagium just behind the femur. A second glance showed that this was no irregular or abnormally precocious development of part of the femoral pterylum, but a line of primary-like sheaths, many of which had a very definitely placed *covert.* The iguana-Archaeopteryx puzzle flashed through my mind and I at once followed up the clue thus given. For the two sketches illustrating my idea of the Tetrapteryx Stage of alar evolution I am indebted to Mr. Dwight Franklin.

PART II.—PELVIC WING.

The detection of this interesting character occurred in August, too late for observations on many forms of nestling birds. I embody in the following notes all that I have been able to gather together on the existence of this curious *pelvic* or *femoral wing.*

WHITE-WINGED DOVE.

Melopelia asiatica (Linn.)

Several of these birds had been reared during the present season in the special breeding cages of the New York Zoological Park. On August 19 a four-days'-old squab, the only nestling of a second brood, was found dead in its nest and brought to me.

Its leaden grey body appeared almost bare, being covered sparsely with the characteristic short, greyish white, filamentous down. Three areas showed precocious development of contour feathers, the wing proper, the pelvic wing and the tail. In the former, twenty-two flight feathers were developed, of which ten were primaries averaging 10 mm. in length, nine were secondar-

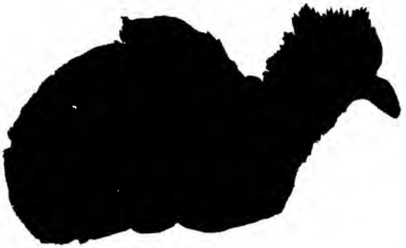


FIG 8 DOMESTIC PIGEON SQUAB

Showing great development of the pelvic wing
The leg is flexed, hence this atavistic
wing is folded

FIG 9 SQUAB OF WHITE-WINGED DOVE

Four days old with wing and leg extended,
showing the wide spread pelvic wing

FIG 10 DETAIL OF PELVIC WING OF WHITE-WINGED DOVE, SHOWN IN FIG 9

The wing consists of twelve flights and six coverts

ies, grading inward from 8 to 5 mm., and three were tiny tertiaries. The primaries had only a single row of strongly developed, greater coverts. Four rows of secondary coverts were sprouting, the central ones pure white, indicating the future color pattern of the wing.

Next in development to the wing proper, were the feathers of what, for lack of a better name, I call the pelvic wing. This seems inexplicable on any other hypothesis than the vestigial secondary plane, which must have been of the utmost importance in the ancestral scaling flight.

This area begins on the anterior outer edge of the crus or leg proper, about one-third of the distance down from the knee. From this place it extends backward across the tibia almost at right angles to the backbone of the body, and, posterior to the femur, following the patagium, which lies between the leg and the body. It ends on the side of the body at an equal distance from the outer tail feather and from the pelvis between the acetabula. The areas are similar on both sides. There are twelve main or flight feathers. Feathers 1 to 6, extending from the body outward along the femoral patagium, all have a well-developed covert. The next six flights, numbers 7 to 12, lie close together on the flesh of the leg itself and show no signs of coverts. Counting from within outward these feathers measure as follows:

Flights	4.5	5.5	5.5	6	6	6	6	5.5	5	4	3	1 mm.
Coverts . .	3.5	4	4	5	5.5	5.5						mm.

The tail is much less advanced than the pectoral and pelvic wings, the rectrices and a single row of upper and another of under coverts being all equally advanced, measuring uniformly 3 mm. in length.

The pelvic wing tract is not apparent in the adult pterylosis of *Columba livia* as given by Nitzsch.[1] Its course is approximately along the upper margin of the crural tract, and continuing toward the tail well into the posterior part of the femoral or lumbar pterylum. In fact, the remaining pterylae of the body are very indistinctly demarcated in the down of this young squab.

[1]Pterylography, Nitzsch, Ed. by Sclater, 1867, plate VII, fig. 2.

DOMESTIC PIGEONS.

Columba livia Bonn. (var.)

The pelvic alar tract is less regular in domestic pigeons than in wild birds, but is remarkably well developed. I give the results of my examination of four squabs taken at random from a large number.

A. The first was about a week old and the pelvic alar tract shows seven flights and four coverts. Always counting postero-anteriorly, the measurements in millimetres are as follows:

Number of feather	1	2	3	4	5	6	7
Length of flights	6	7	8	6.5	5.5	3	2
Length of coverts	4	6	5	3			

B. A squab two weeks old shows ten flights. The posterior four are uniform; they have well developed upper coverts, which are small and lie close above the main feather. From the 5th onward the coverts give place to a row of under coverts. As we go forward, the flights and their coverts become less closely associated, until only the slight difference in elevation of the two most anterior pairs reveals their true relationship. The most anterior flight is isolated and covertless.

Number of feather	1	2	3	4	5	6	7	8	9	10
Length of upper coverts	5	5	5	3.5						
Length of flights ..	6	7	8.5	9	7	6.5	6.5	5.5	4	3
Length of under coverts					4	3.5	4.5	4.5	4	

The precocious development of the feathers of this tract may be realized when compared with those of the true wing and tail in this same bird. The primaries and secondaries are all under five millimetres and the rectrices not more than two in length, while, as we have seen, seven out of ten of the pelvic flights are six millimetres or more, the general average over seven, and the maximum length nine millimetres.

C. A squab about three weeks old shows twelve pelvic flights. The arrangement of coverts is as follows:

Flight No. 1—small upper covert.
2—small upper covert.
3—down covert.
4—down covert.

5—small under covert.
6—down under covert.
7—large under covert.
8—large under covert.
9—large under covert.
10—large under covert.
11—no covert.
12—no covert.

D. A squab of five weeks shows that no additions occur at the posterior end of the pelvic alar tract. The next contour feathers to appear at this point form an ascending series of three, parallel to the backbone and at right angles to the pelvic alar tract. The first four flights with their upper coverts are well grown, far ahead of the rest of the body plumage. The coverts indeed are quite full grown, downy and white-shafted. As in squab C the flights from the 5th onward have under coverts. Altogether there are nine flights with coverts, and three anterior covertless ones.

While considering this newly observed character of pigeons, I thought of the feather-footed breeds and sent for a pair which I carefully dissected. I found no connection between these feather-footed and feather-legged domestic breeds and any unusual development of the pelvic alar tract. The feathers, which have been bred to great length, sprout from the scaly covering of the tarsus and phalanges and not from the leg proper or the femoral patagium, which is the seat of the character under consideration.

JACANA.

Jacana jacana (Linn.)

In a half developed embryo the rectrices and pelvic alar feather papillae are well ahead of all others, even of the wing proper, and are the only ones which show any trace of pigment. In the pelvic alar tract there are four flights and three upper coverts, the anterior flight lacking a covert. In a second embryo, a day or two older, five flights and four coverts are visible in this tract.

GREAT HORNED OWL.

Bubo virginianus (Gmelin)

A brief examination of a living bird showed that the great development of soft plumage on the leg of this species arises from the pelvic alar tract. I was led to expect this from the pterylosis of *Strix bubo,* as given by Nitzsch.[1]

In his figure of *Columba livia*[2] there is, as I have said, no hint of the great development of the pelvic alar tract in the young bird, nor its remarkable disagreement with the lines of demarcation of the pterylae of the adult.

Judging merely from the pterylosis of the adult, many species of *Coraciiformes, Scansores* and *Piciformes* should show most interesting developments of this tract in the young birds.

ARCHAEOPTERYX.

The foregoing observations on various species of living birds were inaugurated and completed before I took up the question in regard to Archaeopteryx. I realized that any trace of this pelvic alar tract which might be present in this ancient bird would be of superlative interest and significance, but until I carefully examined a full-sized photograph of the Berlin specimen I was not aware of the existence of feathers other than those on the wing and tail. I succeeded in finding distinct traces of strongly marked feathers on both sides of the tibia and of still larger feathers, lying between the pelvis and the bent back head. It seemed to me that such very evident traces could not have escaped the observation of other students of this wonderful fossil and I began a search of the literature. I was delighted to find that the tibial feathers had already aroused considerable discussion and I present this in abstract to show how variously the scientific mind has reacted to evidence of this character, unsupported by any other more modern proof. The London Archaeopteryx shows no trace of these feathers, so the whole evidence lies with the single fossil in the Berlin Museum.

[1]Pterylography, 1867, plate II, fig. 9.
[2]Id, plate VII, fig. 2.

The bibliography of this discussion is a short one:

VOGT:
"L'Archaeopteryx macrura.--Un intermédiaire entre les oiseaux et les reptiles." *Revue Scientifique*, 1879, (2) IX, p. 245.

EVANS:
"On portions of a Cranium and a Jaw of the Archaeopteryx," Preface to reprint, 1881, pp. 4-6.

DAMES:
"Ueber Archaeopteryx," *Paleontologischer Abhandlungen*, 1884, II. pp. 39-41.

ABEL:
Grundzuge der Palaeobiologie der Wirbeltiere, 1912, p. 313.

HEILMANN:
"*Vor Nuvaerende Viden om Fuglenes Afstamning*," p. 14. Saertryk of Dansk Ornithologisk Forenings Tidsskrift.

Vogt is the first to mention the feathers whose impressions are visible on the leg of Archaeopteryx. "Le tibia était couvert de plumes dans toute sa longueur. L'Archaeopteryx portait donc des culottes, comme nos faucons, avec les jambes desquels sa jambe a le plus de resemblance, suivant M. Owen."[1]

J. Evans devotes several pages to these feathers and their significance, and a few years later Dames takes issue with him. The following sentences present Evans' view: " . . . . along the outer margin of the right tibia, there is a series of eight or possibly nine feathers of much the same character as those along the tail, and nearly, though not quite, of the same length . . . . Prof. Marsh has, indeed, already suggested that the power of flight probably originated among the small arboreal forms of reptilian birds, and has instanced the flight of *Galeopithecus,* the flying squirrels (*Pteromys*), the flying lizard (*Draco*) and the flying tree-frog (*Rhacophorus*) as indicative of how this may have commenced. Should it eventually prove to be the case that there were what may be termed supplementary wing-feathers on the hinder extremities of such early forms of birds as the Archaeopteryx, his views as to the origin of the powers of flight will be satisfactorily confirmed."

Under the heading "Das Federkleid," Dames devotes considerable space to these tibial feathers. He admits them as

[1]Quite unconnected with the present thesis, but interesting as a sentiment expressed thirty-six years ago, the following paragraph by Vogt is worthy of note: "M. Volger se berçait dans l'espérance que S. M. l'empereur Guillaume achèterait la piecè (Archaeopteryx) pour la conserver à l'Allemagne. Sa Majesté n'entra pas dans ces vues. Ah! si au lieu d'un oiseau, il s'etait agi d'un canon ou d'un fusil pétrifié!"

culottes or what we would call a booted feathering, but denies their function as assisting in flight. Without following his involved arguments, he says in part:

"Zunächst ist es nicht richtig, dass diese Federn dieselbe Consistenz gehabt haben, wie die des Flügels und des Schwanzes, denn sie sind weit undeutlicher erhalten, auch beträchtlich kürzer (Länge durchschnittlich 32 mm. lang) als die Schwanzfedern, welche im mittleren Theil des Schwanzes ungefähr 65 mm. lang sind; . . . . sondern halb so lang . . . . Wenn man aber trotz alle dem doch noch an der Möglich keit, dass Archaeopteryx auch mit den Hinterbeinen geflogen sei, festhalten wollte, so wäre dem noch entgegenzuhalten, dass diese Eigenschaft nothwendig auch irgend welchen Ausdruck im Bau der Knochen der Hinterextremitäten erlangt haben müsste."

The two most recent commenters on this subject differ as completely as do Evans and Dames. Abel in his interesting subheading of "Die mangelhafte Ausbildung des Flugvermögens von Archaeopteryx," writes: "Die zweizeilige Befiederung der Unterschenkel spricht dafür, dass diese Federn den Flug der Archaeopteryx als Fallschirmapparate unterstützt haben."

Heilmann, writing in Danish, gives his opinion in an equally pithy phrase; "it is improbable that the feather coating on the tibia (as assumed by some authors) was of any importance in flight, as it appears too weak.[1]"

PART III.—ARGUMENT.

The pelvic alar tract as I have found it in modern birds is remarkably uniform in position, originating on the anterior outer side of the tibia below the knee, and extending back, along the femoral patagium, to the body and toward the tail. The feathered patagium between the extended leg and the body must have been of the greatest importance, for the feathers sprouting in this area in the young bird are of very large size and invari-

[1]Altsaa rimeligvis paa Overgangen mellem Faldskaermssvaeven (som vi f. Eks. traeffer den hos Flyveegern) og ubehjaelpsom Flagreflugt.

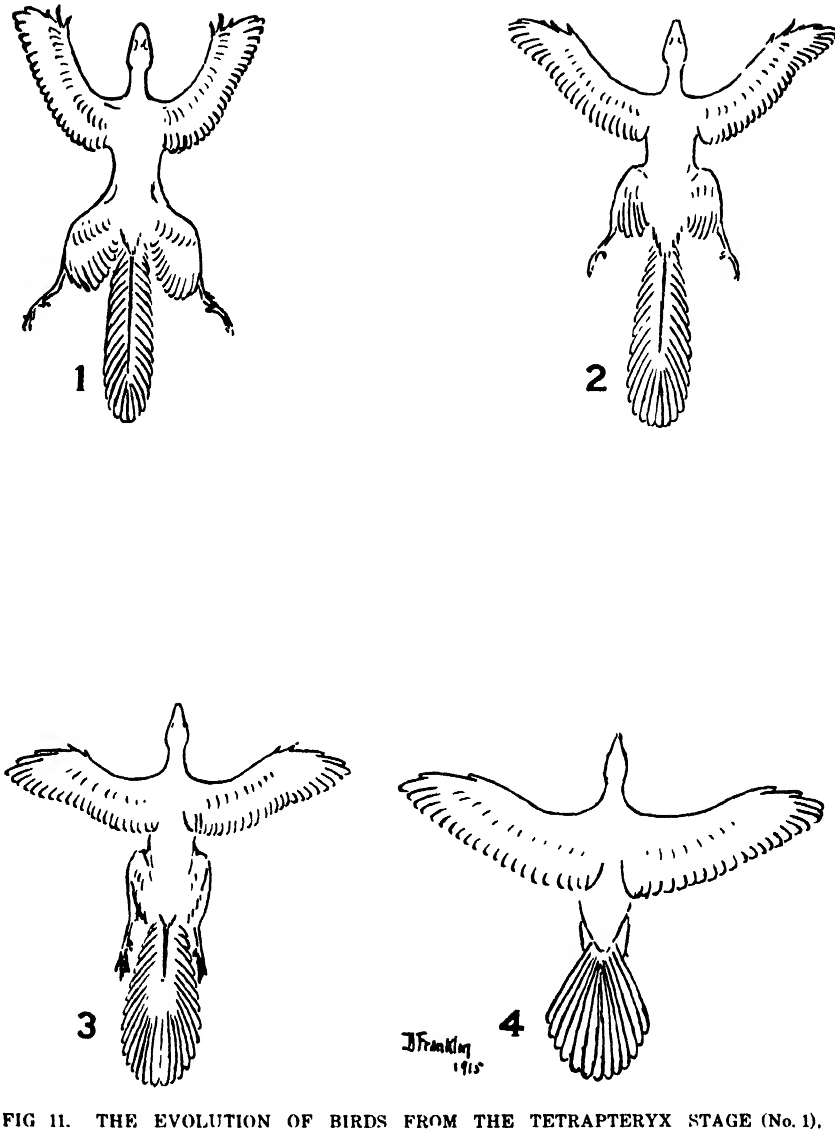


FIG 11. THE EVOLUTION OF BIRDS FROM THE TETRAPTERYX STAGE (No. 1), THROUGH ARCHAEOPTERYX-LIKE STAGE (No. 2), TO THE MODERN BIRD (No. 4).

The principal changes were the feathering and mittening of the fingers; the great strengthening and centralizing of the pectoral wing; the correlated reduction of the femoral or pelvic wing; the shortening of the tail and the concentration of the tail-feathers

ably provided with coverts. This is the pterylum which we hope to find paralleled or directly represented in Archaeopteryx.

The most cursory examination of the fossil reveals the beautifully preserved wing and tail-feathers. Very faint and not at all certain traces have been thought by several observers to represent a ruff of soft feathers at the base of the neck. We have already seen the diverse opinions which the two rows of tibial feathers have aroused. Besides these feathers there have been noted traces of small, soft, covert-like feathers covering the bases of the wing and tail feathers. The remainder of the body has, wholly without reason, been adjudged as scaly. On circumstantial evidence, but equally improbably, others have considered it as quite naked. The most reasonable hypothesis is that the body was fully clothed in soft, rather downy plumage. When the bird died, it fell upon the mud of some river or shore and there, like the remains of gulls which we may find today, it was slowly disintegrated by the elements to a point where all the soft, body plumage was detached and washed or blown away. At the time of being imbedded in the fine silt it retained only the strongly socketed wing and tail feathers and those clinging to the hinder extremities.

The most perfectly preserved part of the London specimen of Archaeopteryx is the tail. From base to tip it is almost without a flaw, and the relative length and position of the feathers are as distinctly seen as in the living bird. The outline of the tail as a whole is like that of a broad, truncated feather, tapering gradually to the base. I mention these details in order to compare them with those of the tail in the Berlin specimen of Archaeopteryx. Here the tip of the tail is lost, but the base is quite distinct. We can observe the same gradual narrowing, due to the increasing shortness of the feathers toward the pelvis. Between the bent-back head and the pelvis, however, we see impressions of feathers which are longer than any at the base of the tail. Their origin is indefinite, somewhere near the pelvis or femur, and they arch up and backward as distinctly as many of the tail-feathers themselves. It seems reasonable to me that this group of feathers, which somewhat resembles a diminutive

wing, may represent the pelvic alar tract which is so remarkably developed in modern squabs.

This character is plainly visible in any good photograph of the Berlin Archaeopteryx. Lankester[1] shows it very distinctly in his reproduction of the fossil. As to the much-discussed tibial feathers, I agree with Evans and Abel that they seem too pronounced in outline to be classed with the downy feathers such as we see on our booted falcons. I think they are the distal elements of the pelvic wing, of far less importance as a *fallschirmapparate* than the larger feathers near the pelvis, which probably arose from the femoral patagium. Most students of this bird have ignored these tibial feathers and in restorations they are usually omitted. Miss Woodward in her artistic plate[2] shows them as soft and fluffy.

Heilmann has approached the general subject of the origin of birds in a most delightful manner. His illustrations show real imagination, using that much abused word in its most admirable sense. Unfortunately his Danish text limits the possibility of wide appreciation. While, as I have shown, he does not believe that the tibial feathers were of volant function, yet, curiously enough, in his very original and dramatic restoration of Archaeopteryx,[3] he has indicated a line of large feathers near the pelvis, which in position correspond to the inner feathers of my pelvic wing.

The argument of Dames against the possibility of the hind leg functioning in aerial activity is at fault. It is naturally impossible to conceive of a skilful flier, flapping with both arms and legs, and with ability for sustained and directive flight, to have evolved such a complicated dermal apparatus without corresponding changes in muscles and bones. But in Archaeopteryx or in our prejurassic Tetrapteryx, the function of the pelvic wings would have been merely passive parachutes. In this early stage, as probably also in Archaeopteryx, flight was merely gliding or scaling. The fingers were too free, the arm bones too delicate, the sternum small or absent, and these facts considered in

[1] Extinct Animals, 1905, p. 238.
[2] Evolution in the Past, Knipe, 1912, p. 96. (II).
[3] Vor Nuvaerende Viden om Fuglenes Abstamning, fig. 11

connection with the small, weak pelvis, makes it impossible to picture the bird as flying skilfully about.

In earlier, lizard-like, aboreal forms, the scale-anlagen of the wing feathers were correlated with corresponding developments along the hind leg, the two increasing equally in size and evolving feather lightness with change in structure.

Even in Archaeopteryx, with its broad, excellent wing, the hand shows little or no correlated adaptation. The absence of two digits has probably no avian, or certainly no volant significance, for we find identical conditions in the manus of carnivorous, bipedal but terrestrial dinosaurs, such as Ceratosaurus, Ornithormimus and Ornitholestes.

If we admit Archaeopteryx to the direct line of lizard—Tet rapteryx—bird geneology, we must conceive of it as having reached a stage where the pectoral wing was becoming dominant, and beginning to afford support to the creature in general. The elongated flight feathers were now extending backward and superceding the passive function of the pelvic wing. With this concentration of motive and supporting power was soon to be correlated a shortening and reduction of the long unwieldy tail.

In succeeding generations the pelvic wings would become more and more reduced. Having arisen from among the surrounding scales, they had, for a time, volplaned through the air of early ages, a character passive and, as future centuries would show, of merely transitory function. Yet they were of tremendous importance in allowing the pectoral scales to develop, to become feathers, and then to assume an importance which was to make the class of birds supreme in the air. Yet the function of the pelvic wings had been so passive and negative that no special muscling had been necessary, no increase nor coalescence of bony tissue. Little by little the line of feathers and their coverts sank again into insignificance and became lost among the body plumage. It affords an excellent example of what Professor Henry F. Osborn would call the phylogenetic accelleration of a character, followed by its gradual reduction.

Millions of years after they were of use, the feathers of the pelvic wing are still reproduced in embryo and nestling. And

for some unknown reason, Nature makes each squab pass through this Tetrapteryx stage. The line of feathers along the leg of the young bird reproduces on this diminutive, useless scale the glory that once was theirs. No fossil bird of the ages prior to Archaeopteryx may come to light, but the memory of Tetrapteryx lingers in every dove-cote.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBERS 3 & 4

No 3. NOTES ON THE BIRDS OF PARÁ, BRAZIL

No 4. FAUNA OF FOUR SQUARE FEET OF JUNGLE DEBRIS

By

C. William Beebe,
CURATOR OF BIRDS

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

February, 1916

FIG. 12. THE CINNAMON TREE OF THE BIRDS
The Utinga Jungle

NOTES ON THE BIRDS OF PARÁ, BRAZIL

By C. William Beebe,
Curator of Birds.

Part I.—Introduction.

Belem or Pará is a city of about two hundred thousand inhabitants. It is a hundred miles from the sea, on the south bank of the Amazon delta, and only one hundred and sixty kilometres south of the equator, built on low swampy land. The birds in the vicinity have been collected assiduously and offer little chance of novelty to the transient ornithologist.

During the first part of May of the present year I had the opportunity of spending a little time in the jungle in the immediate suburbs of Pará. Through the courtesy of the Governor and of Dr. Snethlage I was given the use of a house at the water-works, in a large restricted area of jungle known as Utinga, and here every facility was afforded for collecting and study. Unexpectedly meeting Mr. George K. Cherrie, who had just come down the Amazon, I prevailed upon him to share our opportunities and with my companion Mr. G. Inness Hartley, spent a few days together. I found the region to be of much greater interest than I had expected and by resorting to a rather novel method of observation I obtained a new angle upon life in these tropical lowlands, and one which profoundly impressed me as to future possibilities in this direction.

Part II.—General Ecology.

The Utinga water-works consisted of a pumping station from which radiated long open cement water-ways and closed pipes leading straight through the jungle. The light jungle began at the very edge of the small clearing which was within a few minutes' walk of the tram line leading directly back to the heart of the city.

It was without question quite the hottest, most humid tropical place I have ever encountered. I qualify with humid as I have known the dry heat of India to be much greater, as 110° F. at eleven P. M. at Agra. But this moist heat was in excess of any corresponding temperature I have known in Malaysia, Borneo, Mexico or elsewhere. It was the rainy season and the first day of our stay bore out the reputation of Pará for precipitation, the rain pouring down much of the day. During all of the remainder of our stay, the weather was ideal, clear until about 2:30 P. M., when dark clouds and wind came up, the rain continuing until 4 P. M. On only one day it rained for twenty minutes in the morning, with the afternoon shower as usual. The nights were, of course, cool.

Birds were most abundant from 8 to 10 A. M. and 2 to 5 P. M. while at mid-day, all songs and chirps ceased and only the occasional note of an insect broke the stillness.

Most of the birds had just passed the breeding season, and a goodly proportion of those secured were full-grown young. Both young and adults were molting or just completing the molt. In general they corresponded to our northern birds in August and September. A few, however, were preparing to nest and several were building. Blue tanagers had a nest a few yards from our house with two young which flew on May 8th. Yellow-backed caciques had several small colonies in isolated trees near native houses and were breeding.

Much of the land between the small streams or igarapés was marshy and covered with an almost impenetrable cover of undergrowth. Occasionally a slight rise resulted in dry ground and here the growth became higher, more open and assumed the general character of almost primitive tropical jungle. A narrow trail opened into jungle of this character only a few yards from our house in the pumping-station clearing. It led straight northwards for about two hundred yards when it ended in open, overgrown fields. Along this trail the undergrowth was fairly dense, with here and there a giant buttressed tree, surrounded by lesser trees of many species.

On the first tramp I took in the jungle I noticed a number of small birds in the upper branches of a tree which grew alongside of this trail. Not until I had passed that way several times did I come to realize that this particular tree had some powerful attraction for birds of many species. Knowing the shortness of time at my disposal I determined to concentrate my efforts on this tree which was a species of wild cinnamon. The present paper has to do chiefly with the facts thus obtained.

Once having our attention called to this bird tree, Mr. Hartley and I kept on the watch for others. Several hundred yards away along a pipe line we discovered another. It was a real giant, towering high above all the surrounding growth and we named it the toucan tree as it appeared to be especially attractive to these birds. It was covered with an abundance of good-sized scarlet fruit, the size of which accounted for the presence of medium and large birds such as toucans, caciques, trogons and kiskadees, instead of smaller callistes and flycatchers. A third berry-laden tree half a mile to the eastward straight through the jungle, bore oblong, yellow-skinned fruit appealing especially to woodpeckers and flycatchers, and from the brief glimpses we had as we passed, the constant abundance of birds would have furnished as interesting a list here as at the tree near our house.

I began my study of bird-life in the wild cinnamon tree by stealthy approaches, working my way through the jungle until I was close underneath. I soon found that this was quite unnecessary, as the birds among the upper branches paid no attention either to me or the sound of my gun. Three hours of constant observation beneath the tree resulted in many hours of pain from strained neck muscles. On the third day I brought out a canvas steamer chair and placing it in the trail at a convenient spot, found it to be ideal for observation. I could recline so that looking straight upward was no effort. With gun on my knees, glasses around my neck, note-book and dead birds on a stump within reach, I had discovered a truly *de luxe* method of tropical bird study. The biting flies, gnats and mosquitos made it impossible to sit absolutely quiet for more than a minute, and the ants soon found the legs of the chair gave easy access

to one's person. On the whole, however, I was too much absorbed in the novelty of the method of work and its unexpected results to give any thought to these annoyances.

The principal jungle bloom was the heliconias, whose scarlet, jagged spikes glowed brightly against the dark foliage. Variegated leaves were abundant and when the slanting sun struck through the jungle, it often appeared vivid with color. The jungle about my seat was, of course, more or less impoverished by the nearness of the city and the presence of the waterworks. Black capuchin monkeys of more than one species were hereabouts and I saw as many as nine in a band. Three-toed sloths were common as were agoutis and small squirrels. But during my periods of watching no mammal came near the tree.

The more frequent sounds were the common ones of light jungle, Tinamou called and answered one another, gold-birds lifted their wonderful voices far away in the forest, toucans yelped, caciques squeaked and gurgled overhead, cicadas shrilled and buzzed and great bees and hummingbirds whirred past. The commonest cicada had a note like a person calling a cat *puss-puss-puss* kept up interminably in a high soprano. Another had a shrill, strident note which, when it gained full strength, quavered and broke into two alternating tones, which finally ran together into a true trill. After the daily rain, the tiniest of frogs would each strike up a single, shrill note, unceasingly reiterated. The most memorable sounds were the deep, gutteral voices of great frogs hidden in the igarapés, who reiterated the never answered syllable, wh——y? wh——y?

My business was chiefly with the birds which I could observe from my canvas seat. I spent from two to six hours each day for a period of one week in the immediate vicinity of the tree and during that time identified ninety-seven species of birds, none of which were more than a few yards from the trail. A further division of these is as follows:

Aerial species flying overhead	7
Birds of the surrounding jungle	14
Birds observed in the tree	76

FIG 13 UTINGA JUNGLE FOREGROUND

FIG 14 PARASOL ANTS ON THE MARCH

I shall reserve the details of the various species until later pages, and here give only a résumé of the more general points of interest.

Of the seven aerial species, one was a vulture, one a nighthawk, one a swift and four were swallows. These all came into view at one time or another across the patch of sky visible beyond the upper branches of the tree. Now and then birds of prey appeared, but at such great elevations that I was unable to identify them.

The fourteen birds of the surrounding jungle may be divided thus: one tinamou, dove, woodpecker, kingfisher, trogon, ani and woodhewer, two antbirds, two flycatchers and three finches. In one or two instances these were birds of adjoining fields which had strayed a little way into the undergrowth. The majority, however, were typical of the lower jungle strata, either terrestrial or living in the low undergrowth.

This series of strata of bird life visible to me as I sat quietly hour after hour was very striking, a phenomenon which would never come to one while moving about through the jungle. Bound to the ground were the tinamou, and almost as terrestrial were the rustling ground doves. In the lower underbrush finches, *Synallaxis* and antbirds moved restlessly; a little higher manakins whirred about and woodhewers hitched up the trunks. Then came the birds of the upper branches, callistes, tanagers, flycatchers, toucans and parrakeets. Then the low flyers—the swallows, martins, swifts and nighthawks, and finally the vultures, hanging like the faintest of motes in the sunlight high above the earth.

PART III.—CANELLA DO MATTO AND ITS BIRD LIFE.

The tree which I have already mentioned grew only about one hundred yards from our house at the pumping station and within five minutes' walk of the Pará tram line. It was at the side of a jungle trail, which, while seldom traversed by natives, was kept clear of vegetation by the workmen at the pumping station. It was smooth-barked, richly decorated with lichens and while only about fifteen inches in diameter at a man's height

above the ground, it was very tall in proportion. The first branches were small, mostly dead and about fifty or sixty feet up. From this point the trunk split into lesser divisions and lifted its topmost foliage into the full tropical light and heat a hundred and ten feet above the ground. The berries were small, round and three-parted and, like the leaves, slightly acrid, with a spicy, aromatic flavor.

A few minutes after dawn I have counted eight birds in the tree and a half dozen would sometimes linger until dusk. As a rule, however, there were few in sight until 7:30 or 8:00 A. M., after which there would be a continual coming and going until the heat of mid-day drove all to shelter. The larger number of afternoon visitors came after the rain was over. Sunshine had much to do with the presence of the birds, and a cloudy half-hour meant but scanty notes as I sat beneath. With the reappearing of the sun, the birds would again begin to flock from the surrounding jungle.

Abundance of species and relative fewness of individuals is a pronounced characteristic of any tropical fauna. This was beautifully shown by my first two days' collection from the tree, collecting too, which was quite indiscriminate in character, very different from the more careful picking and choosing with which I shot on succeeding days. The first day I secured sixteen birds, all of different species. The second morning I got fourteen, all different, and only one of which was represented in the lot of the previous day. Thus in five hours' time I secured thirty specimens of twenty-nine species. From the entire district of Pará, three hundred and seventy-nine birds have been recorded. In this single tree within a week's time and during a period of intermittent observation I found seventy-six species.

The bird visitors to the tree arrived in one of two characteristic ways. Many came direct and swiftly, singly or in pairs, flying straight and with decision as if from a distance. A hundred yards away in any direction this convergence could frequently be observed, small birds flying over the summit of the jungle revealing a general flight direction treeward. Another method of arrival was wholly casual, loose flocks drifting slowly from the neighboring jungle, sifting into the tree and feeding

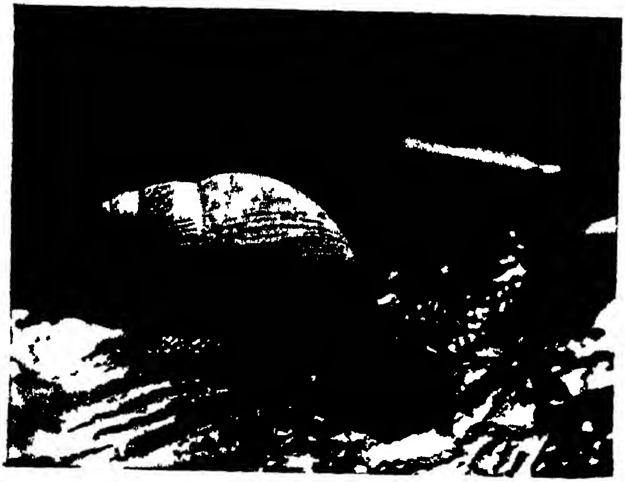


FIG 15 GIANT LAND SNAIL

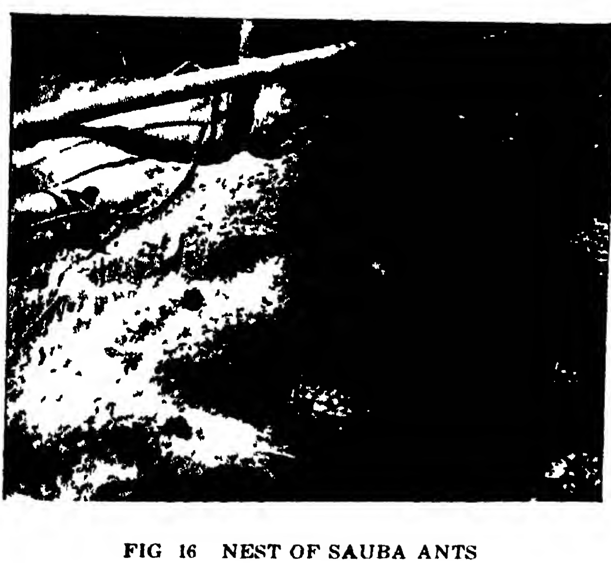


FIG 16 NEST OF SAUBA ANTS

for a time before passing on. When these left it was rather hastily and in answer to the chirps and calls of the members of their flock who had not been beguiled by the berries of this tree and hence had forged steadily ahead.

These more or less well-defined flocks are very typical of all tropical jungles. Little assemblages of flycatchers, callistes, tanagers, antbirds, manakins, woodhewers and woodpeckers are drawn together by some intangible but very social instinct, and unite day after day in these fragile fraternities which drift along, gleaning from leaves, flowers, branches, trunks or ground, each bird according to its structure and way of life. They are so held together by an invisible gregarious instinct that day after day the same heterogeneous flock may be observed, identifiable by peculiarities of one or several of its members. The only recognizable bond is vocal—a constant low calling; half unconscious, absent-minded little signals which keep the members in touch with one another, spurring on the laggards, retarding the over-swift.

At first I found it almost impossible to identify birds unless they were on the lower branches or silhouetted against patches of foliage. When in the upper branches and seen against the sky, birds with under-parts of black, blue or green all looked black. White under plumage appeared grey and buff seemed orange. Even when the tree was filled with the most brilliant callistes, not a bird was visible as long as they were motionless, but when the smallest, most drab of flycatchers moved head or tail I could at once detect it, and distinguish it from the moving leaves about it. Gradually I came to know all the more common species, beginning with the tail-flirting silver-beak tanagers, and before the end of my week's vigil, I seldom made the mistake of shooting a species with which I was already familiar.

While I watched, there came to my tree one species of pigeon, two hawks and two parrots, four hummingbirds and an equal number of toucans and woodpeckers. Fifty-nine were passerine birds of which there were eight each of the families of flycatchers, manakins and cotingas, and eleven tanagers.

Besides the seventy-six species which I positively identified by shooting or observation, I saw at least thirty-three more which eluded me, and of which a hasty glance told no more than that they were of new, and to me, unknown species.

The following is a list of the birds observed actually in the Canella do Matto tree.

COLUMBIFORMES 1

Splendid Pigeon, *Columba speciosa* Gmel.

ACCIPITRIFORMES 2

Brazilian Black Eagle, *Urubitinga urubitinga* (Gmel.).
Plumbeous Kite, *Ictinia plumbea* (Gmel).

PSITTACIFORMES 2

Tuipara Parrakeet, *Brotogeris tuipara* (Gmel.).
Dusky Parrot, *Pionus fuscus* (Müll.).

CORACIIFORMES

TROCHILIDAE 4

Red-vented Hermit, *Phaethornis ruber ruber* (Linn.).
Great Jacobin Hummingbird, *Florisuga mellivora mellivora* (Linn.).
Amazonian Wood-Nymph, *Thalurania furcata furcatoides* Gould.
Green-breasted Fairy, *Heliothrix auriculata phainolaema* Gould.

SCANSORES

RAMPHASTIDAE 4

Red-billed Toucan, *Ramphastos monilis* Müll.
Double-collared Aracari, *Pteroglossus bitorquatus bitorquatus* Vig.
Lettered Aracari, *Pteroglossus inscriptus inscriptus* Swains.

Gould's Toucanet, *Selenidera maculirostris gouldii* (Natt.).

PICIFORMES

PICIDAE 4

Spix's Amazonian Woodpecker, *Celeus jumana jumana* (Spix).

Waved Woodpecker, *Celeus undatus multifasciatus* (Mahl.).

Malherbe's Black Woodpecker, *Campephilus trachelopyrus* (Malh.).

Amazonian Gold-fronted Piculet, *Picumnus aurifrons* Belz.

PASSERIFORMES 59

FORMICARIIDAE 1

Sclater's Amazonian Bush-Shrike, *Thamnophilus amazonicus* Scl.

DENDROCOLAPTIDAE 7

Whiskered Recurved-Bill, *Xenops genibarbis genibarbis* Ill.

Wedge-billed Woodhewer, *Glyphorhynchus cuneatus cuneatus* (Licht.).

Eyton's Fulvous-throated Woodhewer, *Xiphorhynchus guttatus eytoni* (Scl.).

Chestnut-rumped Woodhewer, *Xiphorhynchus pardalotus* (Vieill.).

Picine Woodhewer, *Dendroplex picus picus* (Gmel.).

Layard's Woodhewer, *Picolaptes layardi* Scl.

Buffon's Barred Woodhewer, *Dendrocolaptes certhia certhia* (Bodd.).

TYRANNIDAE 8

Sulphury Flatbill, *Rhynchocyclus sulphurescens* (Spix).

Sclater's Flatbill, *Rhynchocyclus poliocephalus sclateri* Hellm.

Oily Flycatcher, *Mionectes oleagineus oleagineus* (Licht.).

Sharp-billed Flycatcher, *Tyranniscus acer* (Scl. and God.).

Yellow-vented Crested Flycatcher, *Elaenia flavogaster flavogaster* (Thunb.).

Gaimard's Crested Flycatcher, *Elaenia gaimardii guianensis* Berl.

D'Orbigny's Black-headed Flycatcher, *Myiarchus tuberculifer* (Lafr. and D'Orb.).

Azara's Flycatcher, *Empidonomus varius* (Vieill.).

PIPRIDAE 8

Banded-tailed Manakin, *Pipra fasciicauda* Hellm.

Red-headed Manakin, *Pipra erythrocephala rubrocapilla* Temm.

Slate-breasted Black Manakin, *Pipra leucocilla bahiae* Ridgw.

Orange-bellied Manakin, *Pipra suavissima* Sol. and God.

Pará Opal-crowned Manakin, *Pipra opalizans* Pelz.

Schomburgk's Manakin, *Piprites chlorion* (Cab.).

Blue-backed Manakin, *Chiroxiphia pareola pareola* (Linn.).

Eastern White-breasted Manakin, *Chiromachaeris manacus purus* Bangs.

COTINGIDAE 8

Cayenne Tityra, *Tityra cayana* (Linn.).

Red-cheeked Tityra, *Tityra inquisitor erythrogenys* (Selby).

Little Psaris, *Platypsaris minor* (Less.).

Cinereous Thickbill, *Pachyrhamphus rufus* (Bodd.).

Lichtenstein's Thickbill, *Pachyrhamphus marginatus* (Licht.).

Gold Bird, *Lathria cinerea* (Vieill.).

Schomburgk's Attila, *Attila brasiliensis* (Less.).

Cayenne Chatterer, *Cotinga cayana* (Linn.).

TROGLODYTIDAE 2

Swainson's Moustached Wren, *Thryothorus genibarbis genibarbis* Swains.

Venezuelan House Wren, *Troglodytes musculus clarus* Berl. and Hart.

TURDIDAE 1

Cabanis's White-throated Thrush, *Planesticus phaeopygus phaeopygus* (Cab.).

VIREONIDAE 3

Chivi Vireo, *Vireo chivi* (Vieill.).

Grey-naped Wood Vireo, *Pachysylvia thoracica semicinerea* (Scl. and Sal.).

Guiana Vireo-Shrike, *Cyclarhis gujanensis gujanensis* (Gmel.).

FRINGILLIDAE 2

Rothschild's Blue Grosbeak, *Cyanocompsa rothschildii* (Bartl.).

Great Saltator, *Saltator maximus* (Müll.).

COEREBIDAE 5

Brazilian Flowerpecker, *Coereba chloropyga chloropyga* (Cab.).

Turquoise Honey-Creeper, *Dacnis cayana cayana* (Linn.).

Black-backed Honey-Creeper, *Dacnis angelica angelica* Bonap.

Blue Honey-Creeper, *Cyanerpes cyaneus cyaneus* (Linn.).

Green Honey-Creeper, *Chlorophanes spiza spiza* (Linn.).

TANAGRIDAE 11

Blue-backed Green Tanager, *Chlorophonia chlorocapilla* (Shaw).

Northern Violet Euphonia, *Tanagra violacea lichtensteinii* (Cab.).

Cayenne Euphonia, *Tanagra cayennensis* (Gmel.).

Pará Blue-bellied Tanager, *Tanagrella velia signata* Hellm.

Spotted Tanager, *Tangara punctata punctata* (Linn.).

White-shouldered Blue Tanager, *Thraupis episcopus episcopus* (Linn.).

Palm Tanager, *Thraupis palmarum palmarum* (Wied.).

Silver-beaked Tanager, *Ramphocelus carbo carbo* (Pall.).

Scarlet-crested Tanager, *Tachyphonus cristatus brunneus* (Spix).

Pará Crested Tanager, *Tachyphonus surinamus insignis* Hellm.

Guira Tanager, *Hemithraupis guira guira* (Linn.).

ICTERIDAE 3

Great Green Cacipue, *Ostinops viridis* (Müll.).

Yellow-backed Cacique, *Cacicus cela* (Linn.).

Brazilian Red-rumped Cacique, *Cacicus haemorrhous haemorrhous* (Linn.).

The great abundance of birds in this particular tree was due, of course, to the multitude of ripe berries among its foliage. These were the primary cause of attraction. Lacking these, the

birds would have had no special reason for visiting it more than the surrounding jungle. And it was surprising to discover how many of the birds which would usually be considered as fly-catching or insect eaters, had in this case turned frugivorous. It seems worth while to reclassify this arboreal avifauna by the *raison d'être* of their presence.

Feeding on tree berries

Pigeon, 1
Parrakeet, 1
Toucanets, 3
Woodpecker, 1
Flycatchers, 8
Manakins, 6
Cotingas, 7
Thrush, 1
Vireos, 3
Finch, 1
Honey-Creepers, 5
Tanagers, 11
Caciques, 3

Snail-eater

Hawk, 1

Insect-eaters of the trunk

Woodpeckers, 2
Woodhewers, 7

Insect-eater of the branches

Wren, 1

Casual Visitors

Hawk, 1
Parrot, 1
Hummingbirds, 4
Toucan, 1
Woodpecker, 1
Bush-Shrike, 1
Manakins, 2
Cotinga, 1
Wren, 1
Finch, 1

The greedy, noisy parrakeets were restless jungle birds, shifting from one feeding place to another, always gorging themselves, tearing off bunches of berries and wasting much more than they ate. Of the members of the Ramphastidae, the visitors to this tree were almost wholly toucanets, the smaller, more agile species which found less trouble perching on the rather slender branches. The toucan tree a few hundred yards away, hung its larger fruit on stouter branches and attracted the toucans of larger size.

Without exception all the flycatchers which I observed in the tree—eight species—were feeding on the berries, in spite of their wide gapes and insect-guiding bristles. This was not so surprising in the case of the six manakins and seven cotingas, but the three vireos and five honey-creepers must have been birds of originality to turn thus wholly frugivorous. The tanagers led all in numbers, eleven of them, and were feeding exclusively on the berries, and the same was true of the three caciques.

On the casual visitors it is unnecessary to remark. A wren hunted insects among the upper branches one day, and on another a hawk found a giant snail crawling up the trunk and proceeded to devour it.

The insect-eaters of the trunk were nine in number and showed no interest in the berry harvest. Two were woodpeckers and there were seven species of that interesting tropical family of woodhewers. These birds were abundant at Utinga. Their labor was confined to a careful search for insects on the trunk and larger branches. The smaller woodhewers such as *Xenops* and *Glyphorhynchus* usually drifted to the tree as members of the loose jungle flocks. The larger woodhewers were more independent, and usually seen singly or in pairs. The low, plaintive notes of the little wedge-billed woodhewer were typically like those of the loose flocks, keeping the members in touch with one another.

Woodhewers are the very essence of protective coloring, and their habits of life make of them wandering bits of loose bark, yet because of their constant motion, they are very easy to see even in the dim light of the under jungle. The moment they are quiet they vanish, and the keenest eye in the world could not recognize them. This similarity of dress is a remarkable feature of this whole family; big and little, short and long-tailed, with beaks blunt, sharp, straight, curved, thick or needle-thin. In these characters they differ, by these points they must know one another. But their pattern shows little variation. Their olives or browns almost invariably warm into rich foxy rufous on wings and tail, while over head and shoulders a shower of light streaks has fallen, bits of sunlight fixed in down.

And so came to a close my rambling observations on the bird life of this single Canella do Matto. Within the space of a week I had spent not more than twenty hours of neck-racked, vertical observation, shooting whenever necessary, holding up my glasses until my arms collapsed with fatigue. In return I had been able definitely to identify seventy-six species and to record the presence actually in the tree of at least one hundred.

In point of actual numbers I kept no sustained record, but during one vigil of two hours' length I counted four hundred and sixteen birds in the tree.

When I began I had no conception of such success and as I look back and realize the necessary desultory character of my observations, the list seems even more remarkable. Relay observation on the part of two or three watchers for a correspondingly greater length of time, or closer observation from a blind fixed in a nearby tree, would yield notes of incomparably greater thoroughness and value.

Part IV.—Notes on Some Invertebrates Near the Canella do Matto.

I made no effort, during the short time at my disposal, to carry on any lines of observation, other than upon the avifauna of the one tree. Yet as I walked back and forth along the trail, or sat quietly during the rather rare periods when no birds were in sight, or rambled about in the surrounding jungle and along the overgrown igarapés, I made a few desultory notes on certain invertebrates of especial interest to me as forming the food of jungle birds.

The great land snail, *Strophocheilus oblongus* Müller, we saw now and then, partly hidden in crevices of bark, and early one morning I saw a plumbeous kite in the canella tree, holding the shell of one of these mollusks in his talons and devouring the inmate. The shells were strongly grained, and of a rich brown with salmon-colored mouth. An ordinary sized shell was about four or five inches in length, and when the mollusk was fully extended the whole organism reached seven and a half inches. On a tree-trunk leaning over an igarapé I counted four teen of these mollusks crowded into one very shallow cavity.

I observed that spiders entered largely into the diet of the birds I examined and I was interested in watching the method of escape of several common species, whose webs were hung along the trail.

Acrosoma spinosa Linn., an exceedingly spiny, gaudy spider hung in the center of its web. Its scarlet, yellow and black coloring seemed to indicate an unsavory mouthful, and it was correspondingly slow to take alarm. Its large, round web was swung obliquely within a foot or two of the ground. At the center was a heart-shaped open space in which the spider hung by six legs, the other two being drawn back ready for action. The web slanted backward and the spider hung upside down, the brilliant colors of the upper side of the body being thus completely hidden. When the creature was alarmed, it dropped to the ground along a cable which it attached to the point of the heart-shaped space and paid out as it fell. The moment it touched land, it slipped under a leaf. If no further disturbance ensued it regained its courage in about three minutes, and climbed swiftly, winding in its cable and apparently swallowing it, as it went. When caught in the hand, it turned at once upon its back and feigned death.

A mottled, rectangular, rather flattened and much more toothsome appearing spider was *Epeira audax* Blk. Its lure was usually hung under a stump or a fallen sapling. When disturbed it invariably ran upward from the center of the web to the trunk, where it drew in its legs and squatted. In four instances its resting place was a bit of mossy or lichened bark, and although in full view, it merged perfectly with its surroundings. So perfectly, indeed, that the eye had to search carefully to rediscover it each time it sprinted to safety.

Epieira truncata Keys, was a smallish black spider, with yellowish-white markings on its back. It had still a third place of concealment. Wherever its web was hung, there was always some convenient leaf which the spider had half rolled up, tied fast with web and lined with silk. At the first sign of danger or when heavy rain fell, the architect rushed from the center of the web to the prepared sanctuary.

The commonest spider at Utinga, fat, round, black and beloved by birds was *Eriophora purpurascens*. Unlike all the others its point of vantage was not at the center of its web but in a

specially prepared den. The web was invariably hung between the leaves of some shrub. At one side, usually above the web and in full view, three leaves were drawn loosely together and fastened. Between these the spider waited for tell-tale web vibrations, and in such places inquisitive antbirds and jungle wrens found and devoured it.

One day a short distance from the tree I watched an indecisive bout between one of these spiders and a small but courageous wasp. The contest must have been going on for some time as about half the web was already destroyed. The spider had left its den and was clinging to the center of the slack structure. The wasp was exerting every effort to destroy the remaining two or three chief supporting cables. She would alight and chew them with all her might. After a few futile attempts, buzzing with rage, she would fly at the strand, seize it in her mandibles, and darting backward in midair, endeavor to snap it. Then she alighted on a nearby leaf and carefully cleaned feet, wings and head.

After such a rest she would turn her attention to the spider itself, buzzing around as closely as she dared, and making sudden rear attacks.

Eriophora was never off guard for a moment and raising his grasping feet he offered an invincible front. As the wasp was only a fourth of the size of the spider she dared do nothing more in the line of direct attack. It appeared that all her efforts were directed to cutting the spider down to the ground when she could probably have mastered him. He evidently did not dare to attempt to reach his leaf shelter, and remained quiet, guarding against attacks, swaying in his half demolished web. Before any dramatic crisis could develop, a heavy downpour of rain came on and drove both creatures to shelter.

Caterpillars were abundant at this season and remains of them were found in the stomachs of about one bird in every three. The most noticeable, however, were too well-armed to fear sudden death at the beaks of birds. One appeared on the

smooth bark of *Miconia*, like a great felted mass of long reddish hairs, each of which was a veritable barbed and stinging nettle. This larva has never been reared to maturity, but it is supposed to belong to the Limacodidae. These caterpillars climbed slowly up the trunks, making about ten feet an hour.

Another bizarre larva spent the day hidden on the under side of a banana frond, close to the midrib. It looked like a short, thick, arrow, notched posteriorly, with a rounded, blunt head fringed behind with a row of great spikes. The imago is the moth *Opsiphanes invires.*

A sphingine snake-head caterpillar of the genus *Maclorya* was seen once. It is unquestionably one of the most startling dénouements in nature to see this large, smooth, innocuous looking larva suddenly bend its head forward and down, and transform into a vivid representation of a serpent's head, even to the rapidly playing forked tongue.

The omnipresent saüba ants (*Atta* sp.) forced themselves on the attention of the most casual observer. All day long their interminable lines flowed back and forth from tree-tops to nest, conveying myriads of green leaf burdens. The single point which impressed itself upon me was the large number of ants getting free transportation. Every other leaf had from one to six ants of small size clinging to the swaying frond. Where the leaf was pliable and of large size they had all they could do to maintain their position as it was jerked along. These were doubtless some small form of the saüba citizenry but why the free transportation and what their function was I could not determine.

One of the most remarkable invertebrates which I observed was an aquatic hairy caterpillar. This was found in abundance in shallow pools and creeks. The first one which I saw seemed to be wriggling about in the throes of drowning, having, as I supposed, fallen from the overhanging foliage. I charitably scooped it out and set it to dry on a bit of palm leaf. It attempted to walk away, but in spite of the fact that much of its hairy coat dried at once, it staggered about, toppling over at each step and

appearing more at ease squirming about on its side. Some distance further on I saw a dozen more in an open pool and then, realizing my mistaken kindness, went back and restored the caterpillar to its strange element. It seems that this is the larva of a small moth appropriately named *Palustra,* which has assumed an aquatic life. It swims by vigorous wriggles and uncoilings, and occasionally, like a mosquito larva, comes to the surface. It is not known, however, whether it breathes directly from the surface, or from the air entangled in its hairy coat.

PART V.—NOTES ON THE MOLT OF SOME PARÁ BIRDS.

My recent study of the molt, and especially of the tail molt, of pheasants has seemed to yield something of value in dividing these birds into subfamilies.[1] While disclaiming any preconceived belief in the use of this character in other groups, I have nevertheless lost no opportunity to record whatever data I could find in regard to this phenomenon. I intend as rapidly as possible to examine molting birds of all orders and to place the results on record. With this in view I present the facts derived from sixteen species which I examined at Utinga, near Pará, in Brazil in the early part of May. Fragmentary as they are, they show nevertheless that differences exist. Whether these, in some cases, are of only specific distinction, or whether of generic or family value, only future, more extensive investigations can prove.

As regards wing molt, I found only two exceptions to the regular formula of the primaries molting regularly and successively from within out, and the secondaries molting from the outermost inward. In the cotinga, *Platypsaris minor,* the primary molt appeared to be 1-2-3-4-10-5-6-7-8-9. The secondaries had two modes of molt. From the outer to the 4th pair; then from the 5th pair inward and the 12th pair outward, meeting about the 8th pair.

A specimen of *Dacnis cayana cayana* showed a similar break in the secondary molt, molting in both wings inward from the outer pair, and outward from the 9th pair, meeting at the 5th or 6th pairs.

[1]Zoologica. Vol. I, No. 15, p. 265.

In attempting to work out tail molt from dried skins in the Museu Goeldi I was impressed with the difficulty of accurate observation. It is almost impossible to examine thoroughly the entire individual rectrices without damaging the appearance of the skin, and the dried sheaths which are so often the sole clue to recent growth, crumble at the first touch of the pliers.

To summarize at once my data taken from fresh, unskinned birds, I record the following types of tail molt:

Centripetal, from the outside in,

Ramphastidae (3)
Picidae (1)

Centrifugal, from the center out,

Dendrocolaptidae (2)
Vireonidae (1)
Tanagridae (3)

Other types of tail molt,

$\begin{matrix}2\\3\end{matrix} > $ 1-4-5-6 Pipridae (2)

3 — 1-2-4-5-6 Cotingidae (1)

$1 < \begin{matrix}2\text{-}4\\3\text{-}5\end{matrix}$ Coerebidae (2)

Ramphastos osculans *Ramphastidae.*

Two individuals collected from the same flock, May 9, were in almost the same stage of tail molt.

Ten rectrices. Molt from outside in.
Specimen A. Central, 2nd and 3rd pairs, old, unshed.
4th pair, blood sheath of 28 mm.
5th pair, growing 98 mm.

Specimen B. Central, 2nd and 3rd pairs, old, unshed.
4th pair, growing 59 mm.
5th pair, growing 106 mm.

In both birds the mode of molt of the primaries traveling outward had reached the 5th pair. That of the secondaries moving inward, had caused the renewal of eight feathers.

Pteroglossus inscriptus *Ramphastidae.*

Bird collected May 6th.
Ten rectrices. Molt from the outside in.
Central pair, just shed.
2nd pair, one-half grown, 44 mm.
3rd pair, growing, 84 mm.
4th and 5th pairs, new, full-grown.

Selenidera gouldii *Ramphastidae.*

Birds shot May 1st.
Ten rectrices. Molt from the outside in.
Central and 2nd pairs, old, unshed.
3rd rectrice (left), just shed.
3rd rectrice (right), blood sheath, 4 mm.
4th and 5th pairs, new, full-grown.

Celeus undatus *Picidae.*

Bird shot May 6th.
Twelve rectrices, ten functional, and an outer vestigial pair 20 mm. in length. Molt from the outside in.
Central and 2nd pairs, old, unshed.
3rd pair, blood sheath just appearing.
4th pair, growing, 36 mm.
5th pair, almost full-grown.
6th pair, full-grown.

Dendrocolaptes certhia *Dendrocolaptidae.*

Bird collected May 8th.
Twelve rectrices. Molt from the center out.
Central pair, new, full-grown.
2nd pair, nearly grown 96 mm.
3rd pair, blood sheath, 16 mm.
4th, 5th and 6th pairs, old, unshed.

Picolaptes layardi *Dendrocolaptidae.*

Bird collected May 6th.

Twelve rectrices. Molt from the center out.

Central, 2nd and 3rd pairs, new, full-grown.
4th pair, one-half grown.
5th pair, blood sheath, 19 mm.
6th pair, old, unsheath.

Pipra leucocilla *Pipridae.*

Bird collected May 3rd.

Twelve rectrices. Molt nearly complete; probably like that of the following species.

Central, 2nd and 3rd pairs, new, full-grown
4th pair, nearly full-grown.
5th pair, one-half grown, 18 mm.
6th pair, one-third grown, 8 mm.

Pipra opalizans *Pipridae.*

Two individuals collected on May 8th and 9th.

Twelve rectrices. Molt about the same stage in both. The second and third pairs are shed first and simultaneously; next the central, and then in succession the 4th, 5th and 6th pairs. This unexpected type of molt received confirmation from the fact of its occurrence in two individuals shot on successive days, in different parts of the Utinga jungle.

Specimen A. Juvenile male (Fig. 17).

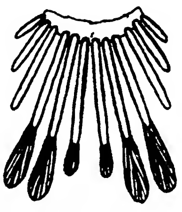


FIG. 17. TAIL OF MANAKIN

All twelve rectrices were blood sheaths, only the central, 2nd and 3rd pairs having broken through.

Central pair, 9 mm.
2nd pair, 11 mm.
3rd pair, 11 mm.
4th pair, 6 mm.
5th pair, 4 mm.
6th pair, 2 mm.

Both wings were exactly alike.

Primaries molting outward; 1st to 5th pairs new.
6th pair nearly grown.
7th pair three-quarters grown.
8th pair blood sheath, 7 mm.
9th and 10th pairs, old, unshed.

Secondaries molting inward; outer pair nearly grown.
2nd pair, blood sheath, 11 mm.
3rd pair, etc., old, unshed.

Specimen B. Adult male.

All twelve rectrices were blood sheaths, just breaking through. The sheaths all averaged 6 mm. in length.

Total Length

Right		Left
11 mm.	1st	11 mm.
14 mm.	2nd	15 mm.
13 mm.	3rd	14 mm.
11 mm.	4th	12 mm.
7 mm.	5th	8.5 mm.
7 mm.	6th	8 mm.

In these specimens the very specialized, opalescent crest feathers were in full molt, almost all of them ensheathed. These sheaths were slender, conical, pointed and lightly fluted. The general appearance of the ensheathed crown feathers was of a mass of obliquely lying, parasitic cocoons on a caterpillar.

Platypsaris minor *Cotingidae.*

Bird collected May 8th.
Twelve rectrices, all old, unshed.

Wings in full molt, both wings the same. Old feathers rufous buff; new ones black, with white basal spots.

Primary molt 1-2-3-4-10-5-6-7-8-9.

Secondary molt, outer to 4th pair.
5th pair inward and 12th pair outward, meeting about the 8th.

Primaries, Inner, 2nd, 3rd and 4th pairs, new, full-grown.
5th pair, nearly full-grown 54 mm.
6th pair, just breaking sheath, 20 mm.
7th, 8th and 9th pairs, old rufous feathers.
10th pair, new, full-grown.

Secondaries, outer pair, nearly grown, 52 mm.
2nd pair, short sheath, 4 mm.
3rd and 4th pairs, old, rufous feathers.
5th, 6th and 7th pairs, new, full-grown.
8th pairs, short sheath, 8 mm.
9th pair, etc., new, full-grown.

Attila brasiliensis *Cotingidae.*

Bird collected May 1st, juvenile.

Twelve rectrices, molt apparently 3-1-2-4-5-6. Old feathers, worn, brown almost rufescent; new ones brownish black.

3rd pair, growing, 40 mm.
1st pair, growing, 21 mm.
2nd pair, blood sheath, 8 mm.
4th, 5th and 6th pairs, old, unshed.

Primaries molting outward, six pairs renewed.
Secondaries show no molt.

Cyclarhis gujaranensis *Vireonidae.*

Specimen A. Bird collected May 1st, female.

Twelve rectrices. Molt from the center out.

Outer four pairs, old, unshed.

Central pair, new full-grown.
2nd pair, growing.

No wing molt.

Specimen B. Bird collected May 1st, juvenile, female.

Twelve rectrices. All old except central pair which are nearly grown.

Dacnis cayana cayana *Coerebidae.*

Specimen A. Bird collected May 3rd, juvenile, female.

Ten rectrices. Molt 1 $< \begin{matrix} 2\text{-}4 \\ 3\text{-}5 \end{matrix}$

Central pair, new, full-grown, 36 mm.

$\left.\begin{matrix}\text{2nd pair} \\ \text{3rd pair}\end{matrix}\right\}$ growing, 27 mm.

$\left.\begin{matrix}\text{4th pair} \\ \text{5th pair}\end{matrix}\right\}$ blood sheath, 11 mm.

Specimen B. Bird collected May 5th, adult, male.

Tail has almost completed molt, outer pairs being nearly full-grown.

Wing molt three-quarters complete, showing an interesting and unusual type of secondary molt. Old feathers edged with green; new ones with blue.

Left Wing				Right Wing
987654321	1234 5 6789, etc.		987 6 54321	123456789
←———	→→	←—	→→ ←—	———→
primaries	secondaries		secondaries	primaries

Secondaries, right wing, outer, 2d, 3d and 4th, new, full-grown.
5th, blood sheath.
6th, old, unshed.
7th, still growing.
8th and 9th, new, full-grown.

left wing, outer, 2nd, 3rd and 4th, new, full-grown.
5th, old, unshed.
6th, blood sheath, 7 mm.
7th, blood sheath, 17 mm.
8th and 9th, new, full-grown.

Chlorophanes spiza *Coerebidae.*

Bird collected May 5th.

Ten rectrices. Molt $1 \begin{array}{l} \nearrow 2\text{-}4 \\ \searrow 3\text{-}5 \end{array}$

Central pair new, full-grown.

$\left.\begin{array}{l}\text{2nd pair}\\ \text{3rd pair}\end{array}\right\}$ full grown

$\left.\begin{array}{l}\text{4th pair}\\ \text{5th pair}\end{array}\right\}$ old, unshed.

Thraupis episcopus episcopus *Tanagridae.*

Specimen A. Bird collected May 9th. Fledgling, male, first day after leaving nest.

Twelve rectrices well grown, and apparently of equal length.

Measurements

Fledgling		*Adult*
19 mm.—	Central	—64 mm.
23 mm.—	2nd	—65 mm.
23 mm.—	3rd	—65 mm.
25 mm.—	4th	—66 mm.
23 mm.—	5th	—66 mm.
21 mm.—	6th	—65 mm.

Specimen B. Bird collected May 1st, male.

Twelve rectrices. Molt from the center out. The whole web of the new feather is blue, stronger on the outer web. Old feathers are black on the inner web, greenish on the outer.

Central pair, new, full-grown.

2nd pair, still growing, 6 mm. shorter than 1st.
3rd pair, unbroken blood sheaths.
4th (right), sheath just appearing.
4th (left), not yet shed.
5th and 6th pairs, old, unshed.

Ramphocelus carbo carbo *Tanagridae.*

Specimen A. Bird collected May 1st, male.

Twelve rectrices. Molt from the center out.

Central and 2nd pairs, full-grown.
3rd and 4th pairs, just drying up.
5th and 6th pairs, not quite full-grown.

Specimen B. Bird collected May 5th, adult male.

Tail in full molt, from the center out.

Central and 2nd pairs, new, full-grown.
3rd, 4th, 5th and 6th pairs, all with 13 mm. sheaths, but total length steeply graduated.

Primaries molting outward, two outer pairs still growing.

Secondaries molting inward, three outer pairs full-grown, next three in active growth.

Tachyphonus surinamus insignis *Tanagridae.*

Specimen A. Bird collected May 2nd.

Twelve rectrices in full molt from the center out, with unusually long time hiatus between the central and 2nd pairs.

Central pair, new, full-grown, 72 mm.

Outer five pairs all with 11 mm. sheaths.

Total lengths 2nd pair, 69 mm.
3rd pair, 54 mm.
4th pair, 40 mm.
5th pair, 31 mm.
6th pair, 25 mm.

Wing molt nearly complete; primaries outward, secondaries inward.

Specimen B. Bird collected May 5th.
Tail completing molt from center out.

PART VI.—ANNOTATED LIST OF BIRDS OBSERVED.

A. BIRDS OF THE WILD CINNAMON TREE.

Columba speciosa (Gmel.) SPLENDID PIGEON.

Three were observed on May 2nd, one in the tree feeding on the berries, the others on adjoining branches. They flew at once when I walked past beneath.

Urubitinga urubitinga (Gmel.). BRAZILIAN BLACK EAGLE.

Twice in the same day this bird visited the trail near the tree, once perching rather low in the jungle and remaining motionless. An hour later it returned and alighted on one of the lower branches of the tree itself, preening its feathers and paying no attention to the small birds scolding from the shelter of the thick foliage to which they had fled. A specimen secured had a large green, blue, red and yellow mantis with a hundred or more of its eggs in his crop.

Ictinia plumbea (Gmel.). PLUMBEOUS KITE.

Early on May 11th at a time when there were only three or four small tanagers in the tree, this bird suddenly appeared. I had stopped watching for a few minutes to rest my fatigued muscles, and on looking up I saw this hawk perched in the tree on a branch, so slender that it was still swaying from the impact of his alighting. He seemed to be picking at something on the branch beside him, but flew at once when I fired, apparently quite uninjured by the small shot which I had to use. I then found that he had been devouring a snail of large size in its shell (*Strophocheilus oblongus*).

Brotogeris tuipara (Gmel.). TUIPARA PARRAKEET.

Quite common in families or small flocks. Twice observed in the tree feeding on the berries, and one which I secured had twenty-three in its crop. The noisiest birds hereabouts. While sitting at the foot of the tree, half an hour would seldom pass without a pair or more of these parrakeets dashing past high overhead, screeching loudly. Other trees seemed to offer more permanent attraction than this one. They showed little fear and members of their flocks could be shot one after the other without frightening the remainder. In the evening they collected in flocks of thirty or forty and circled about high in the air before setting off steadily south-westward toward some distant roost.

Pionus fuscus (Müll.). DUSKY PARROT.

A pair alighted in the tree on May 4th and remained for five minutes before flying off in the direction of the toucan tree. I heard them now and then in other parts of the jungle but did not again catch sight of one.

Phaethornis ruber ruber (Linn.). RED-VENTED HERMIT.

The most abundant hummingbird. Two females spent much of their time searching surrounding heliconia blossoms for tiny insects and resting from time to time on a lower branch of the tree.

Florisuga mellivora mellivora (Linn.). GREAT JACOBIN HUMMINGBIRD.

Thalurania furcata furcatoides Gould. AMAZONIAN WOOD-NYMPH.

Heliothrix auriculata phainolaema Gould. GREEN BREASTED FAIRY.

These three species of hummingbirds were observed perching in the tree on several occasions. Two others were not secured and could not be identified by the glass.

Ramphastos monilis Müll. RED-BILLED TOUCAN.

In the cinnamon tree the visit of this large red-billed toucan was very evidently accidental as the berry-bearing branches were too slight to support his weight. I saw one on May 3rd, resting only for a moment before he flew on in the direction of the toucan tree. When the afternoon's rain was over, the yelping cries of these birds were the most conspicuous sound of the jungle.

Pteroglossus bitorquatus bitorquatus Vig. DOUBLE-COLLARED ARACARI.

Twice observed in the cinnamon tree, and still oftener in the toucan tree. From a flock of eight secured two. Brilliant as these birds are, it is remarkable how easily they escape observation when in the tree-tops. Even when one of a flock is discovered, the closest scrutiny with powerful glasses fails to reveal the remainder, until one by one they move and betray their whereabouts. When motionless they resemble an irregular knot or bunch of leaves. When the broken stub of a branch contains water, they all visit it in turn, drinking after eating a half dozen or more berries.

Colors: iris pale yellow, with a antero-posterior extention of dark brown pigment, giving the pupil an elongated appearance. Bare skin around eye blue, lower lid orange yellow; facial skin same red color as feathers of nape; upper mandible lemon yellow, whitish near base and at tip, black along cutting edge; lower mandible black on terminal two-thirds, greenish-white near base and along ventral line; legs and feet yellow green like the flank feathers.

Pteroglossus inscriptus inscriptus Swains. LETTERED ARACARI.

An occasional visitor to the tree, and when a flock of them came, they made such a commotion that callistes and other small birds could hardly get a foothold. Four out of a flock of five were shot about fifty yards from the tree and the following day the survivor remained near, through most of the hours of day-

light, calling, and now and then feeding on the berries. The first bird shot was a young one and the rest actually followed it to within ten feet of where four of us were standing. Even after the third shot, the fourth bird came as boldly as ever in answer to the yells of the youngster. Bates and other writers speak of being mobbed by toucans in much the same manner.

Of the four birds, two were males, two females. The young molting male had the iris scarlet; crown above eye pale caerulean blue; eyelid, lores, beneath eye and around ear dark livid blue; broad line between eye and ear vermillion; skin back of nostrils bright blue; bill bright orange yellow and black; legs and feet sage green similar to the under tail web. The crop was filled with round, black seeds, which stained everything an indelible dark blue.

Selenidera maculirostris gouldii (Natt.). GOULD'S TOUCANET.

The commonest toucan in the tree, observed on four separate occasions in pairs or trios, but remaining only for a short time and very wary. The iris is lemon yellow above and below, shading off in front and behind into green, which changes to black next the pupil, giving it an extremely flattened, elongate appearance; bill black and white, with the terminal parts of both mandibles pale green; facial skin yellowish and bluish green; legs and feet bluish-green.

Celeus jumana jumana (Spix). SPIX'S AMAZONIAN WOODPECKER.

On May 3rd a single bird hammered at a soft place in the bark of the tree for five minutes, then caught sight of me beneath and fled silently.

Celeus undatus multifasciatus (Malh.). WAVED WOODPECKER.

Observed by Cherrie in the tree on May 5th. Had been eating berries.

Campephilus trachelopyrus (Malh.). MALHERBE'S BLACK WOODPECKER.

Late in the morning of May 6th a pair alighted on the trunk ten feet from the ground and worked their way upward to the small branches before flying off through the jungle. A female collected some distance away had the iris pale orange, bill greenish horn, darker along the culmen; legs and feet deep olive green. Crop filled with large yellow seeds.

Picumnus aurifrons Pelz. AMAZONIAN GOLD-FRONTED PICULET.

While watching a flock of *Dacnis* in the tree early in May, I noticed three small birds which at first glance reminded me of nuthatches. I secured two and found they were curious soft-tailed woodpeckers or piculets. Whether they came for berries or in hope of insect food I cannot say and I did not again have opportunity to observe them. The third bird remained motionless in a neighboring tree for some time. Pará is a new locality for this group, but these individuals seem to be quite typical.

Thamnophilus amazonicus Scl. SCLATER'S AMAZONIAN BUSH-SHRIKE.

While having no real right in an arboreal fauna I must include this species, as a male bird flew up from the underbrush when I shot at it and missed, and alighted for a moment on one of the lower branches. With several other species it was not uncommon in the surrounding jungle.

A few yards from the tree a little earlier in the day, I had stalked the same individual in thick underbrush, where it seemed to be at odds with a white-breasted manakin. After the latter flew off, the Bush-Shrike kept constantly in one place, close to the ground, singing every thirty of forty seconds. It was a simple refrain *whut! whee-whee! whee-whee! whee-whee!* When startled it uttered the *whut!* alone. It was difficult stalking ground but only a loud crackle of leaves made the bush-shrike shift its perch. The female appeared for a moment and the male repeated his song twice very rapidly, and turning close

to her ruffled all his feathers, making himself into a perfect ball, blatantly displaying the usually concealed white patch, and with the spotted shoulders protruding conspicuously from the round, slate-colored mass. Keeping thus inflated he hopped around and around on his perch, completing a half turn at each hop, stopping for a second or two between hops and twisting so as to face her. At this time his song came irregularly. Twice he began it while on the hop, but did not end it. The moment the female slipped away, all his excitement ceased and he went hard at work on his never ending ditty. Once the shadow of a passing vulture fell upon him and cut short the refrain, but only for a moment. Great metallic bees buzzed close about the singer but were not noticed. I later found his crop crammed with small black ants.

Xenops genibarbis genibarbis Ill. WHISKERED RECURVED-BILL.

One seen on the tree, and once shot in the depths of the Utinga jungle.

Glyphorhynchus cuneatus cuneatus (Licht.). WEDGE-BILLED WOODHEWER.

The commonest woodhewer hereabouts, and observed almost every day on the tree, moving creeper-like up and around the trunk. The slightly upward curve of the beak gives to the bird a decidedly nuthatch profile. This species seemed about to nest and two females would have deposited eggs within a very few days. Its low, plaintive note often revealed its presence before it was seen.

Xiphorhynchus guttatus eytoni (Scl.). EYTON'S FULVOUS-THROATED WOODHEWER.

A pair of these large woodhewers were courting, a process which seemed to consist in the constant pursuit of one by the other. This took place along the trail on which the tree grew, and the birds alighted again and again in the tree but not to feed. After resting a moment, panting, they continued their endless

chase. They were silent and only when the pursuer almost caught up did the other utter a sharp, querulous note. So fast did they fly that the two brown bodies would appear like streaks shooting in and out of the tree-trunks. As they were seen in the trail every day their nesting site was doubtless not far off.

Xiphorhynchus pardalotus (Vieill.). CHESTNUT-RUMPED WOODHEWER.

Seen only once and secured from one of the higher branches of the tree.

Dendroplex picus picus (Gmel.). PICINE WOODHEWER.

Next to *Glyphorhynchus* the commonest woodhewer seen near the tree. Once only did one a'ight on it, but others were seen constantly on the adjoining trunks. Owing to the large amount of white it was the most conspicuous of these birds. Several times I saw one alight crossways on a branch, the first time I have ever seen a woodhewer assume this passerine position.

Picolaptes layardi Scl. LAYARD'S WOODHEWER.

Dendrocolaptes certhia certhia (Bodd.). BUFFON'S BARRED WOODHEWER.

I saw neither of these species but I examined specimens in the flesh shot from the tree by Mr. Cherrie in my absence.

Rhynchocyclus sulphurescens (Spix). SULPHURY FLATBILL.

Abundant in tree. A dozen could have been shot at each period of observation, had I wished them. An adult and a young male which were secured were both feeding on the tree berries. The latter was in very much worn juvenile plumage and about to moult.

Rhynchocyclus poliocephalus sclateri Hellm. SCLATER'S FLATBILL.

A male collected in the tree on May 10th had both tree berries and small Diptera in its crop.

Mionectes oleagineus oleagineus (Licht.). OILY FLYCATCHER.

This was the commonest flycatcher which frequented the tree. I secured six and could have shot twenty on any of the days when I was on watch. Its bright buff breast rendered it one of the easiest birds to recognize, and after a day's observation I shot none by accident. Their food consisted both of tree berries and small insects.

Tyranniscus acer (Scl. and God.). SHARP-BILLED FLYCATCHER.

These little flycatchers were rather rare and usually early comers. I secured none after seven-thirty in the morning, and even then they had been feeding for some time. Those collected in the tree had fed altogether on the tree berries. They were breeding at this season. Even with my powerful field glasses, and with knowledge of the points of difference it was absolutely impossible to distinguish this species from either of the preceding forms of *Rhynchocyclus*. When eighty feet or more up, I do not think identification with glasses of these lesser flycatchers can be accomplished.

Elaenia flavogaster flavogaster (Thunb.). YELLOW-VENTED CRESTED FLYCATCHER.

Observed several times in the tree feeding on the berries. It kept lower down than the other smaller species and was recognizable by its clean-cut, white markings.

Elaenia gaimardii guianensis Berl. GAIMARD'S CRESTED FLYCATCHER.

Only among the top-most branches with other small Flycatchers. On two occasions when seen against a mass of dense foliage I detected the half-concealed, white crown, but usually the species merged wholly with the *Rhynchocyclus* and *Tyranniscus* feeding with it. It was feeding wholly on the tree berries.

Myiarchus tuberculifer (Lafr. and D'Orb.). D'ORBIGNY'S BLACK-HEADED FLYCATCHER.

This was the only species of flycatcher which ever got in the least excited over my presence at the foot of the tree. As I was getting into position for a prolonged period of observation, one or a pair of these birds would occasionally drop down from the upper branches and with crest raised, excitedly flutter from one branch to another uttering a continual sharp *tsip! tsip!* While the berries were eaten by all I examined, yet insects were never wholly absent, and more than once I saw birds of this species launch out high above the tree after passing insects. When seen against green foliage, even at a great height, the distinct areas of grey and yellow on the lower plumage were quite distinct.

Empidonomus varius (Vieill.). AZARA'S FLYCATCHER.

A specimen in worn plumage shot from the tree and three others near by. All must have been in the tree during the morning as all had tree berries in their crops.

Pipra fasciicauda Hellm. BANDED-TAILED MANAKIN.

Several times I had watched orange and black manakins in the lower branches of the tree and supposed they were the common red-headed species (*Pipra rubricapilla*). It is very probable that most of them belonged to that species, as all which Cherrie and I secured in the neighborhood of Utinga were *rubricapilla.* The single bird which I secured from the tree was the banded-tailed manakin. In its crop were two small beetles and seven tree berries.

Pipra erythrocephala rubrocapilla Temm. RED-HEADED MANAKIN.

The commonest manakin at Utinga. Early every morning a male would be perched on the same branch of the tree and

twice I saw him driven away by other manakins. He never fed while I watched him, but sat sometimes for fifteen minutes without moving, paying no attention even to the sound of the gun or of the shot as it returned and swished through the leaves after I had fired a shot straight upward.

•

Pipra leucocilla bahiae Ridgw. SLATE-BREASTED BLACK MANAKIN.

Next to the red-crowned this manakin was most frequently seen. It was a female of this species which, with a male opal-crowned manakin, I secured from the tree with one shot. They had united to chase away the red-crowned bird from his perch and at once had flown upward beyond the usual height at which these birds are found. In the upper branches they joined a small flock which had come out of the jungle, and which soon left the tree and went on toward the north.

Pipra suavissima Sol. and God. ORANGE-BELLIED MANAKIN.

After a flock of roving jungle birds had left the tree I secured this specimen from their number. It had two tree berries and a great mass of insect larvae in its crop. I did not observe it again during my stay.

Pipra opalizans Pelz. PARA OPAL-CROWNED MANAKIN.

The female which I secured was in an adjoining tree, but only about twenty feet from the cinnamon tree, and within half an hour the small flocks of manakins appeared from which I got the male bird. There were five berries in the crop, which otherwise was empty. A day or two before seven or eight of these beautiful birds had been secured for Mr. Cherrie two miles away, by a native collector. Aside from these examples we saw nothing of the species.

Piprites chlorion (Cab.). SCHOMBURGK'S MANAKIN.

Shooting at what I took to be a flycatcher of some new species I secured a female of this species from one of the lower

branches. It had been hopping about for some time in the neighboring jungle and its crop contained only small insects. It was quite alone and I saw nothing, nothing of its mate or of other individuals.

Chiroxiphia pareola pareola (Linn.). BLUE-BACKED MANAKIN.

Twice seen and one male secured. On May 5th a male had been flying back and forth for some time before I gave it careful attention. Although well above the ground, it showed its crown and back so distinctly that I knew it at once, and watched it through the glasses snatching berries and chasing some species of *Dacnis* through the branches.

Chiromachaeris manacus purus Bangs. EASTERN WHITE-BREASTED MANAKIN.

Although a day seldom passed when I did not see this species near the tree, it was only on the last day of observation that I saw it actually in the tree itself. Two manakins of unknown species were having a most excited time in the lower branches and making all the noise of which they were capable. The uproar drew two male white-breasted manakins from the jungle undergrowth and they flew up without hesitation to see what the matter was. When they reached the branch the row soon ended and all concerned sought privacy again. A pair was always to be found about one hundred yards from the tree on the edge of the jungle where an old cultivated field had grown up to dense briery undergrowth. A second pair must have had a nest within ten or fifteen yards of the trail, although most careful search failed to locate it. While sitting quietly near the tree the female often came close and peered at me, hopping from twig to twig, and at each flight producing the characteristic deep, low *whirrrrrrrrr!* the wing song by which these little jungle people give vent to their emotions—courtship, suspicion, fear.

Tityra cayana (Linn.). CAYENNE TITYRA.

One of these birds perched for some time in a tree close to our house on the first day of our stay at Utinga. I saw no more

of the species until I found that late in the afternoon just after the rain or even while it was still falling, three of these tityras came to the tree regularly in company with one or two Cotingas. I saw them under these conditions on three separate occasions and watched them feeding on the berries at leisure.

Tityra inquisitor erythrogenys (Selby). RED-CHEEKED TITYRA.

One early in the morning of May 6th. Not seen again.

Platypsaris minor (Less.). LITTLE PSARIS.

At seven A. M. on May 6th the cinnamon tree seemed almost deserted. I arranged my canvas chair and lying back, searched the upper branches carefully with my glasses for signs of life. Suddenly I saw motion in the tip of what I had thought was a broken branch stub. Several minutes passed and as I could make nothing of it, I secured it and found it to be a female psaris. It had evidently been feeding elsewhere as well, as the stomach contained a large yellow seed and a green grasshopper, while in the crop were three tree berries.

Pachyrhamphus rufus (Bodd.). CINEREOUS THICKBILL.

Twice I observed the unmistakable female of this species feeding in the tree, but was unable to secure it. On the following day we shot a specimen some distance away. Its only food was hairy caterpillars. It seems a silent, quiet bird, slow in movement and stupid in taking alarm at the warning cries or flight of other birds.

Pachyrhamphus marginatus (Licht). LICHTENSTEIN'S THICKBILL.

Quite ignorant of what I was shooting at, I secured a female of this thickbill from the very top of the tree where it was feeding in company with callistes and flycatchers. It had breakfasted on a spider and several tree berries.

Lathria cinerea (Vieill.). GOLD BIRD.

The gold or greenheart birds as they are known in Guiana, were found in the Utinga jungle, isolated as usual, vague calling Voices, penetrating and ventriloqual. A great fig ten yards from my cinnamon tree was a favorite perch of one of these birds and twice or more each morning it came to the berry tree to snatch a mouthful of the fruit and dash back again. It would utter its call the moment it alighted, but I never heard it given elsewhere than from this perch in the dense heart of the great fig tree.

Attila brasiliensis (Less.). SCHOMBURGK'S ATTILA.

While observing this species and after I had secured a specimen I supposed I was dealing with some unknown form of flycatcher, although I had never known any member of the Tyrannidae with such a marvellous vocabulary as had these birds. Two individuals, one adult and a young male, were in the tree early on the morning of May 1st and ultimately I secured the latter and identified the species. They were exceedingly active and playful. The full-grown young bird would aproach its parent, fluttering its wings and begging for food, then being chased swiftly through the jungle and back again, or swinging around, would pursue the other in turn. The song, which was uttered every ten or fifteen seconds was exactly alike in the two birds. It was a high, liquid four note phrase, *wheedle-wheedle-wheedle-wheedle!* Four rapid repetitions was the rule, more rarely increased to five or six. But this was constantly varid from the more usual timbre. When uttered while in pursuit of one another it became higher and shriller, or when given as the overgrown youngster was swallowing a berry it was fairly gargled. Again only a single *whee!* would be uttered, standing for some unknown emotion. At least a score of variations or shades of utterance were heard in fifteen minutes. The note of suspicion or alarm, given when I made too loud a noise or when another bird or a squirrel alarmed them, was very different, a loud, sharp, woodpecker-like cackle. After this was uttered once or twice, during which time the birds were motionless, the wheedle call or song commenced, the Attilas becoming at once active.

They kept to the tree-tops and only by a quick, long-distance shot was I able to secure the young bird. The iris was pale hazel-brown; upper mandible horny black; lower also, with a large, fleshy-white patch mid-way along the rim on each side. The inner gape showed the loose yellow skin so characteristic of young birds; legs and feet slaty-blue; soles yellowish-flesh; claws dark brown.

The most unexpected fact was in connection with its food. The crop was full of berries and there were two which had not yet been swallowed, but in the gizzard were the recognizable remains of a small fish. The only way I can account for this unusual item of diet is that the birds must have been drinking at a jungle pool near by in which were many small minnow-like *Tetragonopterus*, and the young bird in some way had managed to seize and swallow one.

Cotinga cayana (Linn.). CAYENNE CHATTERER.

Once or twice these brilliant birds were seen in the mango trees near our house, but like the tityras I did not see them elsewhere than in the cinnamon tree in late afternoons. There were usually two, one in full color and the other a female or young bird. Their brilliance absolutely disappeared when seen against the bright sky, but in contrast with the green leaves or a cloud, lighted by the slanting rays of the sun, they flashed like great gems.

Thryothorus genibarbis genibarbis Swains. SWAINSON'S MOUSTACHED WREN.

For two days in succession a pair of these birds remained in the neighborhood of the tree, occasionally visiting the lower branches, but only momentarily and, as far as I could judge not touching the berries, but intent only on insect prey. One made occasional attempts at song, but the season was evidently past or had not yet arrived.

Troglodytes musculus clarus Berl. and Hart. VENEZUELAN HOUSE WREN.

This is, of course, not a bird of the jungle and its presence in the tree was accidental, and as far as my observation went occurred only once. The bird seen was doubtless one of a pair which lived in and about the clearing about our house, and made deeper foraging inroads now and then into the jungle. It was probably the number and commotion of the small callistes and other birds feeding in the tree which drew the inquisitive wren thither early in the morning on May 6th.

Planesticus phaeopygus phaeopygus (Cab.). CABANIS'S WHITE-THROATED THRUSH.

Not uncommon in isolated pairs through the jungle, and an occasional visitor to the tree especially in late afternoons. They went about feeding in a business-like manner, apparently filling their crops in a short time. The nesting season for them had just begun.

Vireo chivi (Vieill.). CHIVI VIREO.

At 8 A. M. on May 5th I secured this bird from the upper branches of the tree, not knowing at what I was shooting except that it had a different carriage from the flycatchers and dacnis which thronged the upper foliage. Four tree berries were in its crop and a fifth still unswallowed in the mouth.

Pachysylvia thoracica semicinerea (Scl. and Sal.). GREY-NAPED WOOD VIREO.

Cyclarhis gujanensis gujanensis (Gmel.). GUIANA VIREO-SHRIKE.

I secured these birds within ten minutes of one another on May 2nd. Both were feeding on the berries of the tree.

The previous day we had shot elsewhere an adult male vireo-shrike and a young male of the year in very worn plumage. Comparison of these two showed the following differences:

	Adult	*Juvenile*
Length	147	143
Culmen .	16	15
Culmen from nostril	10	9
Wing	70	65
Tail	55	55
Tarsus	20	21
Middle toe and claw	16	17

Bill: adult reddish horn; juvenile slaty grey; tips in both whitish.
Legs and feet: adult brownish blue; juvenile clear slaty blue.
Iris: adult reddish orange; juvenile hazel, paling outwardly.
Bare facial area: adult warm flesh; juvenile olive green.
Forehead: adult rich chestnut; juvenile grey like head.
Superciliary: adult rich chestnut; juvenile warm buff.

Cyanocompsa rothschildii (Bartl.). ROTHSCHILD'S BLUE GROSBEAK.

I saw this bird on two occasions feeding on the berries of the tree, although it was probably the same individual. The second time it descended to one of the lower branches and remained motionless for many minutes.

Saltator maximus (Mull.). GREAT SALTATOR.

Saw but one of this species in the tree and that quite an accidental visitor as it perched only for a few seconds on a lower limb and then flew straight off through the jungle. Two days later we secured a specimen a mile away, but saw no others during our stay.

Coereba chloropyga chloropyga (Cab.). BRAZILIAN FLOWERPECKER.

A few of these little birds were seen almost every day in the tree usually well up near the top, but unlike most of their

companions feeding apparently altogether on small insects. The first one which I saw in the tree was on a lower branch by itself, singing with all its might. Its song was sweet, rather short and of a wheezy character with a quaint little lilt. This in spite of the fact that it was in very worn, shabby breeding plumage.

Dacnis cayana cayana (Linn.). TURQUOISE HONEY-CREEPER.

These exquisite little birds were one of the most abundant species which frequented the tree. I saw at least fifty during each period of two or three hours of observation. All which I secured were feeding on the berries. They usually kept to the upper branches, flying swiftly from the surrounding jungle summits, and moving actively about, now and then catching an insect but preferring the tree berries. This was the only species of the Family which ever came down to lower branches. When well up it was impossible to differentiate between this and the next species. The color of the turquoise honey-creeper is remarkable. When the bird is held between the observer and the light, no matter how oriented, whether sideways, head or tail on, it is a deep cobalt blue; when looked at with the light behind the observer, it is as intense a clear, shining turquoise. There is no position of feather or bird which will alter these colors.

Dacnis angelica angelica Bonap. BLACK-BACKED HONEY-CREEPER.

Still more active than the turquoise, this bird equalled it in numbers, and sometimes twenty were in the top of the tree at one time.

Cyanerpes cyaneus cyaneus (Linn.). BLUE HONEY-CREEPER.

The blue honey-creeper, perhaps the most beautiful of all this group, was much more common at the tree in the afteroon than in the morning. I was able to identify the males of these birds at any height and found them in the proportion of two in the morning to seven in the afternoon. I have counted eighteen individuals at one time. They seldom descended to the lower branches. In every specimen I examined there were a few insects in the crop in addition to the tree berries.

Chlorophanes spiza spiza (Linn.). GREEN HONEY-CREEPER.

The fourth member of this group, glowing with its green iridescence in the sunlight. Instead of insects these birds were plucking tree berries with their long curved beaks. They seemed equally abundant, whether at daybreak or after the daily rains in late afternoon. Eight males and two females were grouped together on one of the central branches for fully five minutes one morning, excited about something which the most careful scrutiny with my glasses failed to reveal.

Chlorophonia chlorocapilla (Shaw). BLUE-BACKED GREEN TANAGER.

This bird which appears to be new to this part of Brazil was shot accidentally. I aimed at a blue-bellied tanager in the tree, missed it, and this small, wonderfully-colored species, which I had quite failed to observe, dropped from an upper branch. It had two tree berries in the crop.

Tanagra violacea lichtensteinii (Cab.). NORTHERN VIOLET EUPHONIA.

Never present in large numbers but several pairs were sure to turn up in the tree during the day. They did not remain long, perhaps, because a berry or two must have made a cropful for such diminutive chaps. No matter how busy hopping about, they always found time every few minutes to stop and burst into their jubilant little song.

Tanagra cayennensis (Gmel.). CAYENNE EUPHONIA.

Decidedly rare in the tree. Saw four and secured one. Easy to identify when not silhouetted against the sky, the two lateral patches of orange feathers standing out in strong contrast with the blue black of the remainder of the plumage. The specimen which I shot had small green seeds in its crop, not those of the tree.

Tanagrella velia signata Hellm. PARÁ BLUE-BELLIED TANAGER.

On May 5th Cherrie shot a female of this beautiful bird from the tree and within five minutes I secured its mate. On three later occasions I observed this tanager, always in pairs and in the early morning. It could not be recognized with certainity in the upper branches as the yellow of the black was usually concealed. They fed greedily on the tree berries.

Tangara punctata punctata (Linn.). SPOTTED TANAGER.

Early visitors to the tree, coming singly or in pairs straight across the top of the jungle as if from a distance. They knew the tree well and began to feed as soon as they arrived. After they had eaten several berries they would appear satiated and either sit in the sun and preen their feathers or chase one another about, always returning from the surrounding jungle for another period of feeding before they left.

Thraupis episcopus episcopus (Linn.). WHITE-SHOULDERED BLUE TANAGER.

Blue tanagers were rare at the tree although common elsewhere, and when they appeared came singly or in pairs. I saw them there only three times. This may have been because they were nesting at this season, a pair of birds having a nest in a mango tree a few yards from our house. There were two young birds and these flew on May 8th.

Thraupis palmarum palmarum (Wied.). PALM TANAGER.

One bird shot in the tree in company with a flock of silverbeaks on May 8th. Its mate fed for some time afterwards on the tree berries. Although fairly common elsewhere on the borders of the jungle no more were observed in the tree.

Ramphocelus carbo carbo (Pall.). SILVER-BEAKED TANAGER.

The commonest bird at Utinga and almost constantly present in the tree. When large numbers of callistes and flycatchers were gathered together there would sometimes be only

one silver-beak. Then with a rustle of wings a whole flock would fly up from the surrounding jungle, twenty or thirty in all, and without actual aggression but by sheer numbers would disturb most of the smaller birds. They would chase other birds half playfully or in turn be pursued by some flycatcher, but on the whole the tree-top assemblage of birds was a peaceful one. The quickest glance served to identify these tanagers, for though their white beak might be invisible, and their plumage appear jet black viewed against the bright sky, the characteristic sideways flirting of the tail never failed. Their sharp metallic *chip!* was another positive factor of identification. They were restless, never remaining very long in the tree but flying off one after the other to work their way slowly through the jungle.

Tachyphonus cristatus brunneus (Spix). SCARLET-CRESTED TANAGER.

One specimen with a number of honey-creepers was secured in the tree early on May 2nd. Did not note another during my stay.

Tachyphonus surinamus insignis Hellm. PARÁ CRESTED TANAGER.

Three or four times I observed this bird at the tree feeding on the berries and secured two specimens. Its peculiar markings enabled me to identify it at almost any height. On May 5th a male suddenly swooped down from the upper branches and showed great agitation upon finding me in my observation chair. I soon discovered that the cause was a female and single young in the undergrowth near by, who were attracted rather than frightened by the emotion of the male. They soon took themselves off, and in a few minutes the male crested tanager was again back feeding in the tree.

Hemithraupis guira guira (Linn.). GUIRA TANAGER.

Early on May 5th a pair of these birds high up in the tree. One of these I secured. The other continued feeding and flying about the tree with honey-creepers and flower-peckers for some time afterwards.

Ostinops viridis (Müll.). GREAT GREEN CACIQUE.

A small colony of these splendid birds was established near the toucan tree, to which tree they paid frequent visits. Only once did I see one in the cinnamon tree and then only for a minute. He snatched two berries, looked carefully about him, down at me and flew off through the jungle in the direction of the colony, a few hundred yards away.

Cacicus cela (Linn.). YELLOW-BACKED CACIQUE.

Five times I saw these birds in the tree feeding greedily on the berries. The slenderness of the branches seemed to bother them, however, and they never remained long. They constantly haunted the toucan tree several hundred yards away, which had larger berries and stouter branches. There were three separate colonies within the radius of a half mile, the nearest only a hundred yards from the tree and from our house in the yard of a native. In certain zones of the jungle the squeaks and gurgles of these birds were the dominant sounds throughout the day.

In spite of this indescribable squeaking and yelping, the yellow-backed caciques appear to have a consistent call or song. It may be written, *yank! yank! yank-keou-ke-wonk!*

Cacicus haemorrhous haemorrhous (Linn.). BRAZILIAN RED-RUMPED CACIQUE.

One individual was in the tree on May 6 with four yellow-backed birds. I could not secure it but watched it for more than five minutes.

B.—AERIAL BIRDS.

Catharista atratus brasiliensis (Bonap.). BRAZILIAN BLACK VULTURE.

Five minutes seldom passed, hour after hour, when one or more of these birds did not soar across the bit of sky visible above the cinnamon tree. Usually they were very high up,

soaring, but occasionally just sweeping the tree tops with their pelican-like habit of alternate flapping and gliding. At sunset scores flew past southward, just clearing the jungle, or else collected on some dead tree until twenty or thirty had assembled, when all flew off in the same direction to some distant roost.

Chordeiles acutipennis acutipennis (Bodd.). SOUTH AMERICAN NIGHTHAWK.

Chaetura spinicauda spinicauda (Temm.). SPINE-TAILED SWIFT.

Tachycineta albiventer (Bodd.). WHITE-VENTED TREE SWALLOW.

Progne chalybea chalybea (Gmel.). GREY-BREASTED MARTIN.

Atticora fasciata (Gmel.). WHITE-BANDED SWALLOW.

Stelgidopteryx ruficollis ruficollis (Vieill.). BRAZILIAN ROUGH-WINGED SWALLOW.

The above six species were observed, the first in late afternoon and the others throughout the day, hawking about in the sky over the tree. None were very rare, the last named, perhaps, the most abundant. In clear weather they flew high, but as the clouds gathered they settled lower, following the shifting strata of volant insect life.

C.—BIRDS OF THE SURROUNDING JUNGLE.

Crypturus variegatus (Gmel.). VARIEGATED TINAMOU.

These tinamou were twice seen and heard daily within a few yards of the cinnamon tree. Their plaintive, sustained note was one of the commonest sounds of the jungle. They would reply to an imitation of their notes and even approach, but never close enough for a shot, and no especial effort was made to stalk them. The only specimen examined was one in the last stages of decomposition which had met its death a few feet from the cinnamon tree trail. It was being skeletonized by ants and there was left barely sufficient plumage for identification.

Geotrygon montana (Linn.). RED GROUND DOVE.

Not uncommon on the jungle floor, flushing with a loud noise of wings, and at first being confused with small tinamou. One which I secured showed no evidence of recent breeding.

Ceophloeus lineatus (Linn.). GREAT LINEATED WOODPECKER.

In late morning on May 9th as I sat watching under the cinnamon tree I was bothered for ten or fifteen minutes by what I thought were two men building a house. The hammering was loud and incessant, and I could tell when first one then the other began work as their boards gave forth varying tones. Often they would go at it together. Finally I heard a resounding rattle, more rapid and staccato than any hammering carpenter could produce, and my suspicion aroused, I walked to the end of the trail at the edge of the jungle. Out in a cleared field stood a headless, weatherbeaten royal palm and to this were clinging a pair of great lineated woodpeckers hammering intermittently and audible half a mile away.

Ceryle torquata torquata (Linn.). GREAT GREY KINGFISHER.

On May 8th one of these splendid kingfishers passed over the tree on its way from one igarapé to another.

Trogon melanurus melanurus Swains. BLACK-TAILED TROGON.

The commonest Trogon hereabouts, more often heard than seen.

Crotophaga ani Linn. COMMON ANI.

Abundant in the surrounding brushy fields, but seldom venturing far into even the more open jungle.

Thamnophilus aethiopes incertus Pelz. PELZELN'S BUSH-SHRIKE.

Not uncommonly seen and heard, and easy to recognize at sight after a specimen has been examined.

Cercomacra tyrannina Scl. TYRANT ANT-WREN.

A common species in the undergrowth of the jungle, frequently seen close to the base of the tree, hopping about or scratching among the dead leaves.

Synallaxis rutilans omissa Hart. PARÁ SPINETAIL.

A pair of these birds were nesting very close to the tree, and were never quite reconciled to my continued presence. Strangely enough, the occasional sound of the gun did not seem to alarm them. They kept rather low down, but five minutes seldom passed without one or the other coming to have a look at me, and voicing its dissatisfaction in a low *chut*. Specimens secured elsewhere showed that this species was both preparing to lay and brooding in early May.

Pipra aureola (Linn.). ORANGE-HEADED MANAKIN.

Not uncommon in the surrounding jungle, and I am almost certain that some of those in the tree itself were of this species.

Pitangus sulphuratus sulphuratus (Linn.). KISKADEE FLYCATCHER.

Conspicuous in appearance and vocally. An inhabitant of the open places but occasionally flying over or alighting on jungle near the tree.

Muscivora tyrannus (Linn.). FORK-TAILED FLYCATCHER.

This unmistakable species was seen several times flying over the tree.

Volatinia jacarini splendens (Vieill.). GLOSSY GRASSQUIT.

Common in the overgrown fields fifty yards beyond the tree at the edge of the jungle. Once a pair flew past down the trail headed for the pumping station clearing.

Brachyspiza capensis capensis (Müll.). CHINGOLO SONG SPARROW.

Heard singing in the nearest open glade and twice seen at the base of the tree.

Arremon silens (Bodd.). PECTORAL SPARROW.

These beautiful sparrows were not rare in the undergrowth at the base of the tree and as I was seated on watch, one or two would now and then flit across the trail with sharp chirps, coming back as closely as they dared to stare at me, hopping about nervously.

FAUNA OF FOUR SQUARE FEET OF JUNGLE DEBRIS

I.

For a week I had been studying the bird-life of a single tree, a Canella do Matto, as I have described in detail in the preceding number of ZOOLOGICA. On the last day as I was about to go, I concentrated my attention on the tree and the surrounding jungle, endeavoring to fix it indelibly in my mind. I realized that in a few minutes I would leave this place with which I had become so intimate, and should very probably never return. I had demonstrated a remarkable concentration of bird-life when attracted by the ripened fruit of a single jungle tree. It was the unparalleled insurgence of such a variety of organisms as can occur only in the tropics.

Now that there remained only a brief space of time I tried to conceive of some last thing I could do to re-emphasize this important phase of tropical life.

As I walked slowly up the trail toward the tree I heard a rustling among the leaves at one side, and in deep shadow beyond a dense clump of scarlet heliconias, I made out a tyrant antwren (*Cercomacra tyrannina*) scratching with all its might. To the kicking power of its small legs it occasionally added sudden flicks with the bill, given with such nice judgment and power, that it flung leaves larger than itself into the air and backward quite over its body. I had often wondered of what the food of these birds really consisted. Anyone could glance at the contents of a crop and gizzard and label it "small insects." But the actual details of this varied bill of fare, except in the case of very recently swallowed objects, was usually merged and lost in the comminuted mass of legs, elytra and antennae.

Acting on this hint I brought from my camping stores an empty war bag, and carefully scraped together a few handfuls of leaves, sticks, moss, earth and mold of all sorts. From directly under the Canella do Matto, I gathered four square feet of jungle debris, filled my bag and shouldered it. Then I said adieu to my trail and my tree, a sorrowful leave taking as is always my misfortune. For the bonds which bind me to a place or a person are not easily broken.

In this case, however, the bond was not altogether severed, and a week later when the sky line was unbroken by land, when a long ground swell waved but did not break the deep blue of the open sea, I unlaced my bag of jungle mold. Armed with forceps, lens and vials, I began my search. For days I had gazed upward; now my scrutiny was directed downward. With binoculars I had scanned without ceasing the myriad leaves of a great tree. Now with lens or naked eye I sought for signs of life on an infinitely smaller scale; the metropolis of a fallen leaf, the inhabitants of a dead twig. When I studied the tree-top life in the lofty jungle I was in a land of Brobdingnag; now I was verily a Gulliver in Lilliput. The cosmos in my war bag teemed with mystery as deep and as inviting as any in the jungle itself.

When I began work I knew little of what I should find. My vague thoughts visualized ants and worms, and especially I anticipated unearthing myriads of the unpleasant macuins, or bête rouge, whose hosts had done all in their power to make life in the jungle unhappy.

For ten days or more on the steamer trip north Mr. Hartley and I labored over the jungle debris. After two hours steady concentration our eyes rebelled and we had to desist. It seemed at times as if the four square feet had increased to forty, but the last handful was finally sifted and teased to shreds. Our method of work was to place a small pile on a newspaper spread on a table under the skylights of the smoking room, and with forceps and dissecting needle to search carefully every surface of leaf and frond and to split every twig and stem.

It was found that the safest way to capture the minute creatures which crawled or hopped about was to wet a small

brush in alcohol, touch them with the tip and float them off in the liquid in a very small vial. Thus they were uninjured and we could pick them from a mass of earth or fungus without including any of the debris itself. Usually we worked with our naked eyes, but occasionally hunted over a particularly rich field with low power dissecting lenses.

Day by day our vials increased. Scores of creatures evaded our search. Many others, of which I had captured a generous number, I allowed to escape. My lilliputian census was far from the mere aggregation of ants and worms which I had anticipated, and a review of the whole showed that hardly any great group of living creatures was unrepresented.

Two objects indicated the presence of wild mammals. First a bunch of rufous hairs which in size, color and minute structure were identical with those of the common agouti, which was very common at Utinga. I also found sign of this rodent. Man himself was represented by two wads which had dropped from my gun-shots sometime during the week. One had already begun to disintegrate, wet, half decayed and inhabited by half a dozen tiny organisms.

Five feathers were the marks of birds, also doubtless the result of my study during the week. A body feather, and two primaries from a sparrow-like bird were indeterminate, but two brilliant, green plumes came without question from the body of a calliste. Of reptiles there was a broken skull of some lizard, half disintegrated with a few of the teeth still left. There was besides the small egg-shell of a lizard which had hatched and gone forth to live its life elsewhere in the jungle. A third reptilian trace may have been his nemesis—a good-sized shred of snake-skin. The group of amphibians was present even in this small area of four square feet—a very tiny, dried, black and wholly unrecognizable little frog. Fishes were absent, although from my knees as I scraped up the debris, I could almost see a little igarapé in which dwelt scores of minnows.

As I delved deeper and examined the mold more carefully for the diminutive inhabitants, I found that this thin veneer from the floor of the jungle appeared to have several layers each with its particular fauna. The upper layer was composed of

recently fallen leaves, nuts, seeds and twigs, dry and quite fresh. As yet these showed but little change, and only the damage wrought by insects and other agencies while they were still on the trees. In this layer were small colonies of ants in hollow twigs and occasional huge solitary ones. Here lived in hiding small moths, beetles and bugs awaiting dusk to fly forth through the jungle. The lowest layer was one chiefly of matted, thready roots holding together compact masses of earthy soil, mixed with a large proportion of tiny bits of quartz. The animal life of this stratum was very meagre, occasional mites—especially red ones—and a few earth and round worms, the latter in much fewer numbers than in the middle layers.

Between the upper and the middle layers were sprouting nuts and seeds, with their blanched roots threaded downward into the rich dark mold, and the greening cotyledons curling upward toward light and warmth. Thus had the great Canella do Matto itself begun life. In my war bag were a score of potential forest giants doomed to a death in the salt ocean.

The middle layer, finally, was the all-important stratum. In it lived four-fifths of the small folk. This was composed of debris in full course of disintegration; leaves, sometimes partly green, usually brown or black, nuts half decayed, twigs half rotten. All still preserved their form, although some were ready to fall apart at a touch. All were soaked through, or at least damp and soggy. Often four or five leaves would be stuck together, stitched with the threads of fungi. In such a haven was always a host of living organisms.

Some of the half decayed leaves were very beautiful. Vistas of pale, bleached fungus lace trailed over the rich mahogany colored tissues, studded here and there with bits of glistening, transparent quartz. Here I had many hints of a world of life beyond the power of the unaided eye. And here too the grosser fauna scrambled, hopped or wriggled. Everywhere were tiny chrysalids and cocoons, many empty. Now and then a plaque of eggs, almost microscopic, showed veriest pin-pricks where still more minute parasites had made their escape. Contracting the field of vision to this world where leaves were fields and fungi loomed as forests, competition, the tragedies, the mystery

lessen not at all. Minute seeds mimicked small beetles in shape and in exquisite tracery of patterns; small beetles curled up and to the eye became minute seeds of beautiful design. Bits of bark simulated insects, a patch of fungus seemed a worm, and in their turn insects and worms became transmuted optically into immobile vegetation. Scores of little creatures were wholly invisible until they moved. Here and there I discovered a lifeless boulder of emerald or turquoise—the metallic cuirass of some long dead beetle.

Some of the scenes which appeared as I picked over the mold, unfolded suddenly after an upheaval of debris, were startling. When we had worked with the lens for many minutes, all relative comparisons with the surrounding world were lost. Instead of looking down from on high, a being apart, with titanic brush of bristles ready to capture the fiercest of these jungle creatures, I, like Alice in Wonderland, felt myself growing smaller, becoming an onlooker, perhaps hiding behind a tiny leaf or twig. This feeling became more and more real as we labored day after day, and it added greatly to the interest and excitement. Close by would appear, under the lens, piles of great logs and branches protruding from a heaped up bank of precious stones. Mauve, yellow, orange and cerulean hues played over the scene. Over a steep hill came a horned, ungainly creature with huge proboscis and eight legs, and shining, liver-colored body, all paunch, spotted with a sickly hue of yellow. It was studded with short, stiff bristles, and was apparently as large as a wart hog and much more ugly. It was a mite, one of the biting mites of the tropics, but under the lens a terrible monster. We put one of these on our arm to see if its bite corresponded to that of the legions of macuins which tortured us daily in the jungle. Under the lens I saw the hideous creature stop in its awkward progress and as it prepared to sink its proboscis we involuntarily flinched, so fearful a thing seemed about to happen.

In the middle layer, that of most active change, and surcharged with life, ants were abundant, together with small colonies of termites. These were the only social insects, the twigfuls consisting of from five to fifteen members. All the

other organisms were isolated, scattered here and there. Life in these lowly places, so far beneath the sunlight, is an individual thing. Flocks and swarms are unknown, and the mob has no place here. Each organism must live its life and fulfil its destiny single-handed. Even when two individuals were found together it was apparently more through accident of environment than from any gregarious instinct. In fact the same tropical law which holds good in regard to plants and the larger creatures of the sunlighted world overhead applies here. I found numbers of different species, but very few collections of individuals of the same kind.

Flatworms were rather rare, but small, white ones were found now and then flowing slowly along in their characteristic manner over the surface of damp, half decayed leaves, as flatworms do the world over. Roundworms, small, white and threadlike were present in equally small numbers. Earthworms of small size, one or two inches in length, were common. They moved slowly along in orthodox angleworm fashion until something alarmed them when they instantly became a maze of twisting, snapping curves, dancing all about in a most unwormlike fashion. The head and especially the collar were brightly colored, from reddish to an intense scarlet.

Centipedes and millipedes were common, all small, in keeping with the diminutive size of the other inhabitants of this little world. The largest centipede was less than an inch in length and scurried along on eighty-four legs. Very few were dark colored. Almost all were dead white, with yellowish brown heads and jaws. The larger millipedes were slow moving in spite of their abundance of feet, but small ones of various species were very agile, and slipped in and out of fungi forests in a most disconcerting way. They were about evenly divided between the groups of Polydesmoidea, Julioidea and Gerphiloidea.

Scorpions were decidedly rare, and two small and one medium sized specimen were all we could discover. Pseudoscorpions, however, were abundant and conspicuous. I secured fifty, and could have taken three or four times as many. They would rush out excitedly when disturbed, and unlike all the other creatures of the underworld did not seek to hide. Instead,

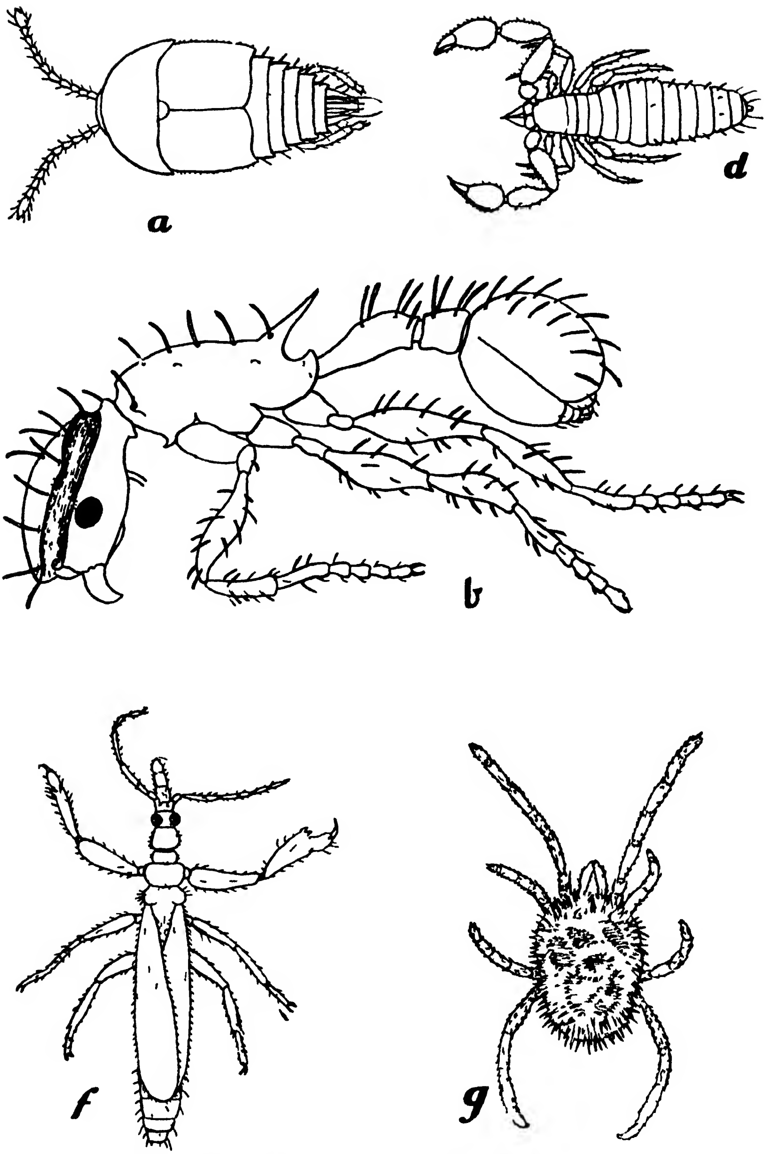


FIG 18 REMARKABLE INSECT FORMS CHIEFLY NEW
Found in the surface of a Tropical Yard of Jungle

a An unknown form beetle, roach or cricket *b*, The worker of a new genus and species of ant *Blepharidatta brasiliensis* Wheeler an extraordinary form with small-eyed workers fitted for a subterranean life The general structure is very simple and primitive *d* Pseudoscorpion or false scorpion a member of a compact, widely distributed family of Arachnida with a pronounced superficial resemblance to true scorpions *f*, Unknown, even as to order *g* A mite, one of the vast host of *bête rouge*, or maquins, the most troublesome pests of tropical jungles

they bravely sought open spaces, walking slowly and feeling ahead with their great pincer-tipped arms, which they brandished with the greatest ease, although these weapons were as long as their entire bodies. When really alarmed, they scurried backward, holding up their chelae in readiness. Their bodies were whitish, but their arms and pincers deep reddish brown. While there were several species, these superficially fell into two distinct types. The most abundant kind was pot-bellied, with heavy chelae, and was slow in movement. The other had a narrow, lighter body and very delicate slender chelae, and ran with great speed when alarmed. These, however, always ran forward, not backward like the others.

Harvest men were represented by a single daddy-long-legs which looked decidedly out of place among this dense debris. I rather fancy he was strolling on the surface when my onslaught bagged him and his surroundings.

Very small and very pale colored spiders lived in the middle layer in fair numbers. We saw about two score altogether. They were usually slow or moderately gaited, like their more abundant relatives, the mites. Only twice did we see a spider dash off with any of the speed which characterized those which lived in the jungle above ground.

Next to the ants the mites and ticks were the most abundant organisms. Hardly a leaf or bit of mold was free from them. We could have gathered hundreds. They were of many species and all colors, red, brown, purple, black and flesh. Some were naked and shining, others clothed in bristly hairs to their very feet. All were repulsive, slow, and so awkward that it was inexplicable how creatures with such lack of correlation could ever manage to find food, much less a mate. They were always crawling slowly along, tumbling over every obstacle in their path. Ticks were much rarer than mites.

Numbers of very simple insects were common. Silverfish or Thysanura of several species ran like active little ghosts out of their hiding places and scurried swiftly to another which they fancied safer. Their nimble movements made them exceedingly difficult to capture. Collembolas, almost equally primitive, were usually white, but now and then a purple one appeared. Not

only were they capable of active running, but when the brush wet with alcohol was about to touch them, they leaped to a distance of twenty to thirty times their own length. Again and again this enabled them to escape. When they landed they remained motionless for some time and were most difficult to discover. Among the specimens collected were Campoclea, and many individuals of Collembola, belonging at least to three different genera *Isotoma, Lepidocyrtus* and *Schöttella.*

Termites, or "white ants," lived in small colonies of six to thirteen individuals in small twigs, in the upper layer of debris. Sometimes they seemed to be living in close association with real ants with no signs of hostility on either side.

A very few immature wood roaches represented the order Orthoptera, while the Hemiptera or true bugs had only a slightly better showing. Earlier stages of these insects lived in the middle layer, while those in the upper were quite adult and were ready to fly.

Beetles of small size were abundant and of numerous species. Of about fifty which I gathered, about sixty per cent were rove beetles. All the others were slow travellers, or on discovery pretended to be dead, but the rove beetles were very agile, and never lost any opportunity of trying to escape capture. There were members of Rhynchophora of the Tribe Tylodini; of the Families Thorictidae, Phalacridae, Pselaphidae and Tenebrionidae. Also of Clivina, Scyclonaenus, Oxytelus, and Platystethus; Staphylinidae were, as I have indicated, by far the most numerous.

Some tiny flies had apparently just emerged from their pupae in the upper layer, these being the only representatives of their order, while of the Lepidoptera there were only two small moths among the dry leaves of the top stratum.

Ants were the most abundant form of life, both in numbers and species. They lived in the upper layers and with the exception of the great, black, solitary fellows who apparently had been walking about on the top of the leaf stratum, all were of small size. Their colonies were apparently complete but very small, a very small twig being packed full of individuals from six to fourteen in number with a half dozen pupae.

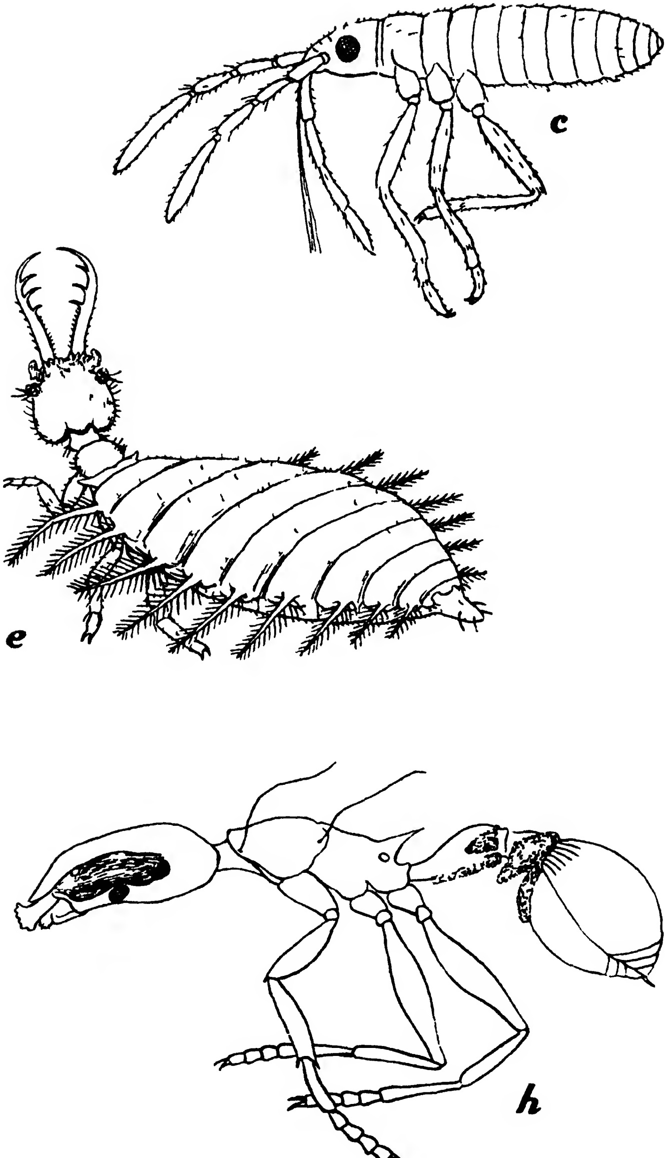


FIG. 19 REMARKABLE INSECT FORMS, CHIEFLY NEW
Found in the surface of a Tropical Yard of Jungle

c Unknown form *e* An unknown form, possibly the remarkable larva of some Myrmeleonid species, related to the Ant-lions *h*, The worker of a new genus and species of ant, *Glamyromyrmex beebei* Wheeler This is also a subterranean form, living in small colonies in tiny twigs In the colony from which the species was described, there were only three workers three females and two males.

Finally mollusks were found in small numbers, all very small, some with flat shells, others with steeply turreted ones. These were young specimens of two species of *Leptinaria* and several very young *Polita,* or *Vitrea* as it is more generally called.

In addition to all these was a host of unknown forms, immature or in some unrecognizable early stage of development. Some had huge jaws and the body encircled with a dense chevaux-de-frise of horny, frond-like spikes. Others were so simple that their relationships could only be guessed at.

One thing was evident early in my exploration. I was having to do with a world of small people. No insects of large size were in any layer of the debris. The largest would be very small in comparison with a May beetle. Another fact which impressed me was the durability of chitin. The remains of beetles, considering the rareness of living ones, was remarkable. The hard wing cases, the thorax armor, the segments of wasps, eyeless head masks, all these still remained perfect in shape and vivid in color. Even in the deepest layers where all else had disintegrated and returned to the elements these shards of death were as new.

Day after day as I worked with my face close to the mold, I was constantly aware of the keen, strong, pungent odor. It hinted of the age-old dissolution, century after century, which had been going on. Leaves had fallen, not in a sudden autumnal down-pour, but in a never ending drift, day after day, month after month. With a daily rain for moisture, with a temperature of three figures for the quicker increase of bacteria, and an excess of humidity to foster quick decay, the jungle floor was indeed a laboratory of vital work—where only analytic chemistry was allowed full sway, and the mystery of synthetic life was ever handicapped and ever a mystery.

Before the vessel docked we had completed our task and had secured over *five hundred* creatures from this lesser cosmos. At least twice as many remained, but in making calculations I estimated that the mold had sheltered a thousand organisms that were plainly visible to the eye.

When I had corked my last vial and the steward had removed the final pile of shredded debris, I leaned back and thought of the thousand little creatures in my scant four square feet of mold. Then there came to mind a square mile of jungle floor with its thin layer of fallen leaves sheltering many more than six billion of these creatures. Then I recalled the three thousand straight miles of continuous jungle which had lain westward up the course of the Amazon, and of the hundreds of miles of wonderful unbroken forest north and south. My mind faltered before the vision of the unnamable numerals of this uncharted census, of the insurgence of life which this thought embraced. It seemed quite clear that no Tyrant Antwren need ever go hungry, as long as he had strength to turn a leaf.

Leaving out the hints of vertebrates which in numbers were almost negligible, the lower types of creatures may roughly be grouped as follows:

Flatworms (Platyhelminthes)	2%
Roundworms (Nemathelminthes)	2%
True Worms (Vermes)	3%
Myriapods (Myriapoda)	6%
Scorpions (Scorpionida)	1%
Pseudoscorpions (Pseudoscorpionida)	8%
Harvest men (Phalangida)	1%
Spiders (Araneida)	3%
Mites and Ticks (Acarida)	14%
Silverfish (Thysanura)	2%
Collembola (Collembola)	3%
Termites (Isoptera)	10%
Roaches (Orthoptera)	1%
Bugs (Hemiptera)	2%
Beetles (Coleoptera)	10%
Flies (Diptera)	1%
Moths (Lepidoptera)	1%
Ants (Hymenoptera)	30%

As shown by this list, ants were the dominant form of life, so I have chosen to mention these in detail as representative of the interest of this method of investigation. They have been thoroughly worked out by Prof. Wheeler,* and the unexpected result of this mode of intensive study is well illustrated by a paragraph from one of Prof. Wheeler's letters. Referring to the nineteen vials of ants which I had sent him he says: "I have just found time to mount them up and to my surprise discover among them representatives of two new and remarkable genera! That you should have found these is indeed remarkable, because Professor Goeldi, formerly the director of the Pará Museum, collected ants very assiduously in that region and sent them to Forel for description. Moreover, one of my students, Mr. William M. Mann, who has been with me several years, collected very extensively in Brazil and recently enumerated all the known Brazilian forms with a description of the new species he had taken, and neither of these men came across the two very peculiar little ants which you found. I take it that they did not work in the leaf mould as you did and that probably when other collectors adopt your method an extensive ant fauna will be unearthed even in Brazil, which has been pretty well worked for ants within recent years. . . . I have named the two new genera and species *Blepharidatta brasiliensis* and *Glamyromyrmex beebei*."

The seventeen species of ants which I discovered in this four square feet of jungle mould are as follows:

1. *Pachycondyla harpax* Fabr. (workers).
2. *Euponera (Trachymesopus) stigma* Fabr. (workers).
3. *Ponera opaciceps* Mayr. (workers).
4. *Anochetus mayri* Emery (deälated female).
5. *Solenopsis subtilis* Emery (workers, males, deälated female).
6. *Crematogaster victima* F. Smith. var. (deälated female).

*Two new Genera of Myrmicine Ants from Brazil, Bull. Mus Comp Zool. Harvard, LIX, No. 7.

7. *Pheidole flavens* Roger subsp. *exigua* Emery (soldiers, workers, males, deälated female).
8. *Pheidole subarmata* Mayr. (workers, deälated female).
9. *Trachymyrmex* sp. (deälated headless female).
10. *Cyphomyrmex rimosus* Spin. (deälated female).
11. *Rhopalothrix* (*Octostruma*) *balzani* Emery (workers, deälated female).
12. *Strumigenys subedentata* Mayr. (deälated female).
13. *Prenolepis steinheili* Forel (workers, males).
14. *Rhizomyrma goeldii* Forel (workers).
15. *Camponotus* (*Myrmothrix*) *abdominalis* Fabr. var. (deälated female).
16. *Blepharidatta brasiliensis* Wheeler.
17. *Glamyromyrmex beebei* Wheeler.

The solitary deälated females of the species of numbers 4, 6, 9, 10, and 15 were evidently establishing colonies. At least eight of the species, those of the genera 2, 3, 5, 11, 12, 14, and the two new genera 16 and 17 are hypogaeic or subterranean ants, with small-eyed workers. With the exception of numbers 1 and 15, all of the species are small or very small.

Taking ants alone, we thus find that in numbers they formed about thirty per cent of the visible fauna of the jungle mould. With the exception of the two species all were adapted by their small size to life in the leaf mould, and fifty per cent were structurally fitted for subterranean existence.

III.

I have made a single interesting comparison between this fauna of four square feet of tropical jungle debris and that of a corresponding area in a temperate and an Arctic latitude. In the tropical material, as I have stated, we found, at the very lowest estimate, one thousand visible organisms. In four square feet of leaves and moss from an uncleared area in the woods of the New York Zoological Park were two hundred and sixty creatures. From a slightly larger area, approximately a square yard, of tundra moss from Labrador, twenty-seven living organisms were unearthed. This last material consisted chiefly of

white reindeer moss, near a grove of fir trees from the North West River on Lake Melville, ninety miles directly west of Rigolet up the Hamilton Inlet. For this I am indebted to A. Sheard, Esq., of the Grenfell Association, who was kind enough to gather it personally for me.

The value of this comparison is, of course, relatively superficial, but nevertheless it is not without interest and should stimulate effort in this comparatively unworked ecological field.*

Fauna of Four Square Feet	*(New York) Temperate*
True Worms (Vermes)	14%
Myriopods (Myriopoda)	10%
Pseudoscorpions (Pseudoscorpionida)	1%
Harvest Men (Phalangida)	4%
Spiders (Araneida)	8%
Mites and Ticks (Acarida)	1%
Silverfish (Thysanura)	3%
Bugs (Hemiptera)	8%
Beetles (Coleoptera)	8%
Moths (Lepidoptera)	1%
Ants (Hymenoptera)	40%

The lists speak for themselves, the interesting facts being the marked diminution in number of general groups, as well as species and individuals from the tropics northward. The dominance of ants in both temperate and tropical cases is worthy of notice, and the remarkable number of true worms in the north and of mites and ticks in the south. In none of the lists are eggs or cocoons included.

Attempts to identify the tropical organisms have shown how little knowledge we have of the life histories of these invertebrates. It was indeed fortunate when even a genus or subfamily could be told. The lack of a great central museum, library and collection of types in our country is keenly felt, as well as the handicap of the general habit of publishing new species in all sorts of magazines and periodicals, wholly unrelated except by the widest of zoological bonds.

*Consult W. L. McAtee, Science, N. S., Vol. XXVI, pp 447-449, and N. Banks, id. p 637.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBER 5.

THE GAFF-TOPSAIL

(*Felichthys felis*)

A SEA CATFISH THAT CARRIES ITS EGGS IN ITS MOUTH

BY

E W GUDGER

STATE NORMAL COLLEGE

GREENSBORO, N. C.

PUBLISHED BY THE SOCIETY

THE ZOOLOGICAL PARK, NEW YORK

AUGUST, 1916

CONTENTS

FIGURES

FIG. 20. GAFF TOPSAIL CATFISH

Lateral view of a female, nineteen and one quarter inches long. From a drawing from life.

THE GAFF-TOPSAIL

(*Felichthys felis*)

A SEA CATFISH THAT CARRIES ITS EGGS IN ITS MOUTH[1]

BY E. W. GUDGER,

STATE NORMAL COLLEGE, GREENSBORO, N. C.

INTRODUCTION.

At the 1908 meeting of the North Carolina Academy of Science, I gave a short paper on the oral gestation of this fish, but, not being ready to publish, the title only appeared in the proceedings published in *Science* (vol. XXVII, p. 991) and in the *Journal Elisha Mitchell Scientific Society* (vol. XXIV, p. 50).

For the Washington meeting of the American Association for the Advancement of Science in 1911, I prepared, but was unable to give in Section F., a paper bearing practically the same title. However, there was published in *Science* (1912, vol. XXXV, p. 192) an abstract, the data of which forms the closing paragraph of this paper.

Since the more technical data obtained in this research will be presented in a series of papers which will require several years for working up and for publication, it has seemed best to give without further delay an account of the search for incubating males of the Gaff-topsail and of the difficulties met with in obtaining and hatching the eggs, and to present the general data concerning this very interesting phenomenon together with the natural history of the fish.[2]

[1]Contribution from United States Fisheries Biological Station, Beaufort, N. C. Published by permission of the Commissioner of Fisheries.

[2]I have pleasure in recording here the hearty thanks due my friends among the fishermen of Beaufort, N. C., for testimony as to the carrying of eggs by the fish, for advice as to where and how to take the fish, for specimens, and for a vast deal of arduous manual labor involved in the very extensive seinings carried on for six years. My especial thanks are due to Jack and Southey Mades and Henry Congleton; to W. E., C. F., and J. W. Wheatley; and to Wilbur Whitehurst, Arthur Newkirk, Pete and Billy Garner, Ed Simpson and Walter Longest.

THE SEARCH FOR THE GAFF-TOPSAIL.

HISTORICAL ACCOUNT.

On July 26, 1906, while at Cape Hatteras, N. C., in company with Mr. N. F. Jennett, a pound-net fisherman of Pamlico Sound at that place, I was informed that, on the preceding day while looking over the fishes brought in from his nets, Mr. Jennett had found in his hands some catfish eggs having young on them. By their flat barbels, he had readily identified these little fish as Gaff-topsails in contradistinction to the other sea catfish. The eggs, he thought, were about the size of peas or slightly larger, but whether they came out of the mouth or the vent he could not say.

On returning to the laboratory of the Bureau of Fisheries at Beaufort, N. C. to which I was at that time temporarily attached as investigator engaged in research work in fish embryology, I began to look up the literature with a special reference to the egg-carrying habits of the catfishes and of other fishes.

This search has been kept up ever since, but the literature has been found to be so voluminous that only the data gathered in 1906 will at this time be reviewed. This is given in brief form that it may afford the reader something of an historical setting for the data to be presented herein. However, it is my purpose to publish at some future time a paper now in MS. reviewing the literature of the world on oral gestation in teleostean fishes.

Evermann and Bean, in 1898, in their "Report on the Indian River and its Fishes," say of *Galeichthys milberti,* a near relative of the Gaff-topsail, that "Mr. Stypman of Stuart, Florida, assures us that eggs are never found in this catfish, but that the young are brought forth alive. He says during March the adult females are found filled with well-developed young, each rolled up in a ball, and the various balls connected in a long string. He thinks they hatch out very much like the sawfish. Others give the same information and it sems certain that this species is ovoviviparous."

Evermann and Goldsborough in 1902 in their "Report on Fishes Collected in Mexico and Central America" describe another allied but heretofore unknown form, *Conorynchos nelsoni,*

which carries its young in its mouth. This was a freshwater catfish taken in southeastern Mexico, from the Rio Usumacinto, 125 miles from its mouth. Two fish were collected, both males; of these one, 13.5 inches long, had one egg in its mouth, the other, 16 inches long, had thirty-nine eggs in the oral cavity at the time of its capture. Eight or ten other fish were captured at the same time but none carried eggs. All the eggs of the second fish save four were lost. These four after being in alcohol for two years averaged 10/16 of an inch in diameter.

Jeffries Wyman, while United States Consul at Paramaribo, Surinam, South America, had his attention called in 1857 to certain Siluroid fishes belonging either to the genus *Bagrus*, or one closely allied, which were said to carry their eggs in their mouths. These reports he verified by visits to the markets where these fish were offered for sale for food. He found either eggs or larvae in the mouths of various specimens of *jarra-bakka* and *njinge-njinge*, and was assured by the negro fisherman that *koepra* and *makrede* together with one or two forms had the same habit. The egg-carriers in all the fishes examined by him were males. The eggs of *jarra-bakka* ranged up to three-fourths of an inch in diameter. Of *njinge-njinge*, eight specimens nine inches long were examined. The eggs were in different stages of development, and the number contained in the mouth varied between twenty and thirty.

Günther in 1864 noted this curious habit in specimens of *Arius fissus* from Cayenne in the same region of South America. In fishes six to seven inches long, all males, he found some twenty eggs about the size of a pea, having on them advanced embryos. This habit, he observed, is not uncommon among American Siluroids.

In 1866, Boake described oral gestation in two species of Ceylon catfishes of the genus *Arius*. Their ova were "large" (he seems to have made no measurements of either ova or fish) and immediately after deposition are "taken up either by the fish that has laid them or by another of the same species, and, not swallowed but kept in the mouth until they are hatched and able to take care of themselves, a period of some weeks." Later he ascertained (presumably by dissection) that the egg-carrying fish was the male.

Boake sent to England some specimens of these fishes (two males and one female) which, coming into the hands of William Turner, were described by him in 1867. He confirmed Boake in all respects, and noted that one of his male specimens had ten eggs in its mouth, whereas one of Boake's specimens had thirteen. The other male, like the female, had the oral cavity empty. The "large" ova were about the size of grapes or small cherries and possessed embryos well along in development, measuring 1/2 to 7/10 of an inch in length. Some of Boake's specimens reached Günther also and he in 1866 described and named them. He commented on the habit of the male in carrying the large eggs in the spacious cavity of the mouth, and compared the fish with *Arius fissus* from South America, previously (1864) described by him.

In 1889, Day described the oral gestation of the males of two genera of Indian catfishes, *Arius* and *Osteogeniosus.* The former had eggs averaging .5 to .6 of an inch in diameter, and each carried as many as fifteen to twenty eggs in the mouth. The eggs were in stages of development varying from very early embryos to larvae nearly ready to take care of themselves.

Günther in his "The Study of Fishes" (1880), p. 160, has the following brief reference: "The Siluroid genus *Arius*, the males of which take care of their progeny, produces ova 5-10 mm. in diameter." On the same page, he gives a figure of the ovum of the *Arius boakei* marked "natural size" but measing 14 mm. in diameter. Finally Jordan in his "Guide to the Study of Fishes," (1905), vol. 1, p. 128, writes: "In certain sea catfishes (*Galeichthys, Conorynchos*) the male carries the eggs in his mouth, thus protecting them from attacks of other fishes." Again, in vol. II, p. 179, he says: "In most or all of the sea catfish, the eggs as large as small peas are taken in the mouth of the male and there cared for until hatched."

Having exhausted the literature in the library of the laboratory, I turned to the fishermen of Beaufort and began the taking of testimony, and was surprised to find how many of them had observed in a general way and now gave such unanimous testimony that the eggs are carried in the mouth. One man thought that the eggs came out in strings, another was not sure on this point, but his best recollection was that this was true,

while another believed that they were hung in bunches in the roof of the mouth. All united in declaring that the eggs came out of the mouth and not out of the vent and that in size they were about equal to peas. One man phrased it that "The sea cat spits its young out of its mouth"; and all affirmed that when the fish are struck on the head or thrown into the boats, the eggs would fly out of their mouths. Boake credits the Ceylon fisherman with reporting a similar phenomenon when the egg-carrying *Arius* of that island is captured, the eggs being voided in such numbers that they are gathered from the bottoms of the boats and used for food.

Several other fishermen testified that the eggs are always carried in the mouth, sometimes as many as two handfuls, but not necessarily of the same age, and that they may be found in May and June. One man declared that the eggs were sometimes as large as the yolk of a small hen's egg and that they were "of a pinkish color between white and blood-red."

Data Obtained in 1906.

Structure of Spent Ovaries.

About this time, August 3-6, 1906, there were found in the laboratory pound net considerable numbers of Gaff-topsail catfish, all of which were brought in and examined. The ovaries presented some very interesting structures, but no extended description of them will be gone into here. They were of the ordinary teleostean type, bifurcated in front, but united behind to form the short oviduct which opens out in the urinogenital pore behind the anus. In the ovaries, only the anterior region bore eggs of any size, some of them being as large as small peas. Each of these eggs was enclosed in an investing follicle richly vascularized and was carried on a short pedicel. The middle section had only pedicels from which the eggs had broken away—the follicles having disappeared probably by resorption—together with small, almost microscopic ova in between. The posterior or oviducal part was very curiously plicated or folded longitudinally like the oesophagus of the frog and so abundantly vascularized that while alive it was of a rich beef-steak-red color.

Until August 13, our pound net daily gave us several of these catfish, the females predominating. These fish were all dissected and from the reduced condition of the reproductive organs—the ovaries running 2 to 2½ inches in length—it was clear that the breeding season was long over and that no further work could be done during this summer. Fig. 20, frontispiece, shows one of these spent females, but it might well represent a non-breeding male since there is nothing to distinguish the two sexes at any time other than the breeding season.

The structure of the ovary of *Felichthys*, in conjunction with the reported habits of *Galeichthys*, seemed to indicate that possibly the fish was viviparous, that the eggs might descend into the oviduct and there remain until hatched, nourished by transfusion of oxygen and food materials from the richly vascularized walls of the oviduct by which they might become partly enveloped. On the other hand there were the positive statements of a number of fishermen, men who presumably knew what they were talking about, that the fish incubated the eggs in its mouth. In this state of uncertainty, the question, owing to the lack of material, had to go over until the next summer.

The Search Continued—June-July, 1907.

Structure of Ripe Ovaries.

As soon as it became known that I had reached the Beaufort laboratory in June, 1907, the fishermen began to look out for catfish material for me. On June 4 they brought in a 21-inch female Gaff-topsail catfish which they had split open from snout to anus without finding any eggs. They had even cut into the ovary, following the idea, which had been advanced to them the previous summer that the eggs were possibly carried there, but had found in this only eggs still bound up in their stalked follicles. This ovary was about 4½ inches in length and was crowded with eggs in size from 10 mm. down. Having never before seen such enormous eggs in a teleost and finding ruptured follicles from which eggs had been evaginated not many days before, I came to the conclusion that these eggs must be ripe and that 10 mm. was the normal size for such.

Two days later the same men brought in two Gaff-topsails which had been caught but a few hours before and which were unmutilated. One fish, 16¾ inches long, proved on dissection to be a female with ovaries 3½ inches in length from tip to opening of oviduct. These organs were much distended with eggs 15 mm. in diameter, and occupied 50 to 60 per cent. of the body cavity. The second fish, also a female, was 21 inches long and had the most enormous and remarkable ovaries I had ever seen in any fish. They were 5½ inches long, tightly distended with eggs from 18 to 20 mm. in diameter and occupied from 75 to 85 per cent. of the body cavity. The other organs were very much reduced in size and crowded out of their normal position.

On June 13 there was brought in from our fyke net a 22-inch female with an ovary 5 inches in length, which by its flabby condition showed plainly that the season's eggs had been lately discharged. From all this mass of evidence it was clear that the breeding season of *Felichthys* was at hand, but, being intently occupied with the completion of another research in fish embryology, I was unable at the time to devote myself to this problem.

A week later, my other investigation having ended, I was ready to take up this research; but our fyke net having ceased to yield specimens and the much-expected new pound net having failed to arrive, the fishermen were called on to help.

The Finding of the Fish with Eggs in the Mouth.

On June 22, we went to the Narrows of Newport River some seven miles northwest from the laboratory. Here where the river proper enters the estuary of the same name, there are oyster reefs at the edges of extensive mud flats. As the tides swirl around these reefs, they dig out deep holes and in these holes the catfish congregate at low tide when their mud flat feeding grounds are nearly laid bare. At the uppermost of these reefs, after several unsuccessful hauls elsewhere, a big catch of Gaff-topsails was made. The number of these was unfortunately not noted, though the lengths of thirty-two egg-carriers were recorded. Probably there were from sixty to seventy-five of them in all.

From the mouths of these catfish there were obtained between 200 and 300 eggs. This is a minimum estimate, for, in the confusion and excitement due to such good fortune, no record was kept and afterward at the laboratory other eggs (to be described later), as they died, were put in the same bottles in which this day's catch was preserved. The fact that all these save thirteen were put into killing fluids was due to this same confusion and excitement which was enhanced by the threshing about of sharks and rays and the splashing of a large number of small fishes in the bottom of our boat, together with my being called on every minute to receive a new lot of eggs. Fortunately at the very last of the haul it occurred to me to try to carry in to the laboratory one of the ovigerous males, and to make sure that the thirteen eggs contained in the mouth were not lost, this was loosely sewed up with a bit of small cord. Although the fish was then put into a bucket of water which was renewed from time to time, it died, but the eggs reached the laboratory in good condition and when put into running salt water soon recovered and seemed perfectly normal.

In this connection Wyman may be quoted that in the bagre of Surinam "In many instances the foetuses were still alive through the parent had been dead for many hours." The context not indicating that the parent had been kept in water, it is probable that these larvae had lived because the moisture in the mouth of the parent had kept the egg-shells damp and hence permeable to oxygen.

Omitting small numbers, one catfish gave up eleven eggs, another thirteen, another fifteen, and others sixteen, twenty, twenty-one, twenty-six, the total amounting as stated above, to between 200 and 300 eggs. These eggs showed considerable variation in size, the extremes being from about 17 to 25 mm. in diameter, the average being from 18 to 20 mm. Their large size and great weight together with the extreme fluidity of their yolks, made them very difficult to handle for fear of hurting the embryos lying on the dorsal side. These embryos, as examination later showed, were in different stages, from that wherein the future fish was in the form of an axial rod with forming eye vesicles, to the young in the black-eyed free-tailed stage about 17 mm. long.

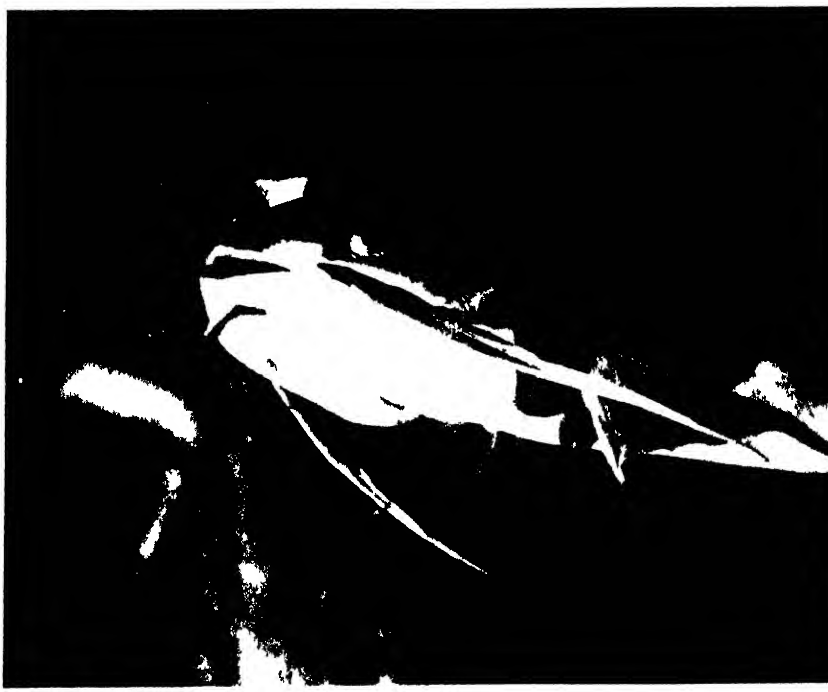


FIG 21 HEAD OF AN EGG CARRYING MALE GAFF TOPSAIL CATFISH

The photograph shows the depressed floor of the mouth and the distended gill covers

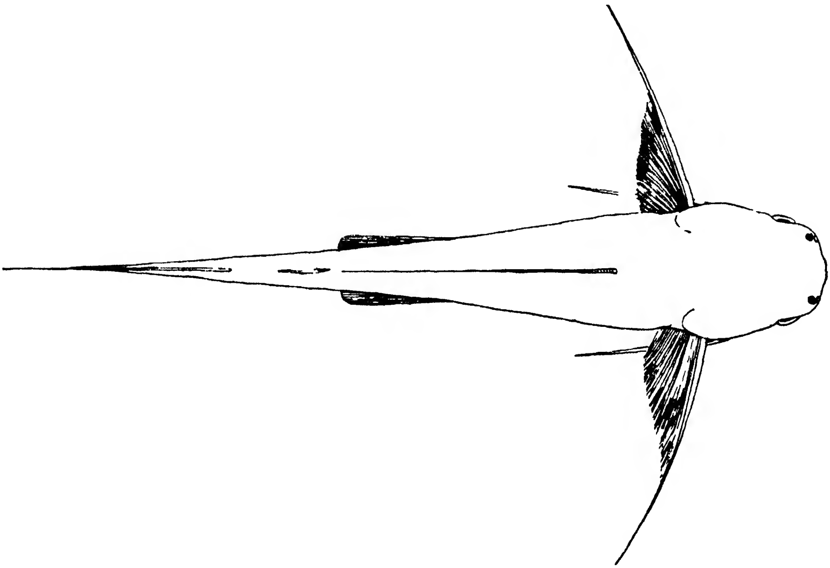


FIG. 22. GAFF-TOPSAIL CATFISH FROM ABOVE
The large head and prominent gill-covers give the fish a marked tadpole appearance. Pen sketch from a specimen 17½ inches long.

The method of procedure in obtaining the eggs was very simple. The fishermen, standing in water and mud up to their waists "fished" in the net, keeping the lead line on the bottom to prevent the escape of any fish. As the net came in the fishermen would grasp the fish just back of the head and in front of the dorsal spine, and keeping their mouths shut to prevent the escape of the eggs, would turn to the boat; then holding the fish with its tail upward, they would allow the eggs to fall or run out into a vessel of water. After being looked over for a minute, or counted in case there was a considerable number of them, they would be transferred to the killing fluid to make room for others.

On this trip only some half dozen egg-carriers were dissected, but in every case the fish was ascertained to be a male. In all the testis was small, stringy, often almost insignificant in size, indicating that the breeding season was past. With the proof by dissection that the male is the carrier of the eggs, the Gaff-topsail catfish falls in line with all other egg-carrying catfishes.

The eggs were loosely held in the mouth, some being pushed into the spaces between the branchial arches, but nowhere was there any evidence of arrangement. It was very noticeable that the mouth cavity, ordinarily so large as to be called enormous, was increased by a distension of the branchial region, but even more noticeably by a marked outpushing or rounding out of the whole hyoid and branchiostegal region. Instead of being flat or insunken as in most fishes and as in all the Gaff-topsails save ovigerous males, this region showed a rounded contour corresponding to the enlargement of the oral cavity, giving the fish a "double chin" appearance.

Figure 21 is a photograph of the head of a living male Gaff-topsail carrying eggs in his mouth. Note the depressed hyoid region and the out-spread gill covers. The mouth is held somewhat closed to prevent the escape of the eggs. Figure 22 is a pen drawing of a living Gaff-topsail, 17½ inches long seen from above. Attention is called to the great size of the head and especially to the width in the region of the gill covers.

Several other collecting trips were made during the summer of 1907 and considerable numbers of eggs were obtained. In one batch of eggs the embryos averaged 20 to 25 mm. in length and fully 3 mm. wide from inside of eyes, while their tails were about half as long as the bodies. Black pigment was noticeable along the dorsal region, the caudal fin rays were visible, and the yolk blood-vascular system was well developed, giving the eggs a beautiful pink or reddish color. (Here recall the fisherman's description.) The heads of the little fish were deeply sunken in the yolk and even the tails occupied little grooves. In this connection an interesting correlation was noted. The heads of the little fish were all twisted, right or left, only one eye being visible, and likewise the tails were twisted right and left. If the right eye was sunk, then the tail was twisted to the right, and vice-versa. This may be seen by careful inspection of figure 23 made from a photograph of the live eggs. However, it seemed to be a matter of indifference to which side the body was bent, for of the 114 eggs on hand, fifty-four had the embryos bent to the right and sixty to the left.

The last trip for 1907 was taken up Newport River on July 18. Again former experiences were repeated, for no catfish

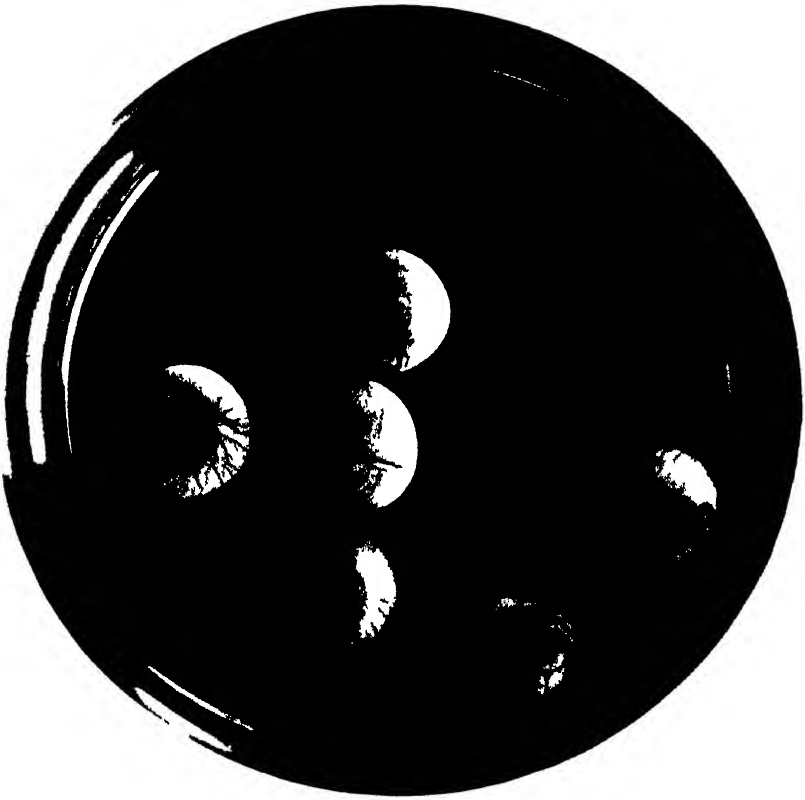


FIG. 23. EGGS WITH LARVAE

Showing the insunken heads, curled tails and prominent yolk circulation

From an instantaneous photograph

were taken until the mud bottom of the upper oyster reef was hauled. Here was secured one male, 18 inches long and from his mouth were taken 21 actively wriggling larvae, one of which was lost. One of these, of average size, died on its way to the laboratory (probably having been injured in being taken from its father's mouth). After being hardened for 24 hours in 10 per cent. formalin, it measured as follows: Length all over from point of snout to tip of upper lobe of caudal 57 mm.; width, between eyes outside to outside, 11.25 mm.; length of dorsal spine, 14.65 mm. The yolk was 18 mm. in diameter measured in the long axis of the fish, and 16.5 mm. in diameter at right angles to the above—the vertical measurement or depth of the fish was unfortunately not noted. On these fish the black stippling was quite thick on the head and along the dorsal region of the body. It was thickest at the roots of the dorsals and on the body it was arranged in distinct lines following the myomeres. Although the eyes were well along in development, the faint choroid slit could still be seen on the ventral side. The anal papilla showed as a projection in the center of a triangle formed by the pelvic and anal fins. In the nasal region, between the two orifices, a flap-like papilla-shaped organ was noticeable.

Figure 31 shows these little fish in the stage of development referred to. It is from an instantaneous photograph made in direct sunlight. The larvae are as yet unable to lift their heavy yolks. Their mode of progression is by "skating" on their yolk sacs over the smooth bottom of the aquarium.

Further Search, 1908-12.

My summers during the years 1908-1912 were spent in the Fisheries Laboratory at Beaufort in strenuous endeavors to fill out my embryological series of the eggs of the Gaff-topsail and to find out if possible how the eggs are transferred. In this work the few successes were interspersed amid many failures. Had artificial fertilization been possible the first task would have been much lightened, and had the fish been small enough to keep in even large aquaria, the latter might have been possible. But as it was I was never able to get breeding males and females at the same time save once and then artificial fertilization failed; while for the second point there was no tank in the laboratory

large enough to hold these considerable-sized fish. In addition there were other hindering causes which at times defeated all efforts to collect the ovigerous males. A brief recital of these will enable the reader to form an idea of the great difficulties under which research in the habits of fishes is pursued. Later the difficulties met with in the effort to hatch the eggs will be discussed.

Difficulties Due to Heavy Rains.

In 1908 I reached Beaufort on the afternoon of May 28. On the following day 4.02 inches of rain fell. On May 22 it had rained 3 inches, and the total rainfall from May 22 to 29 was 7.79 inches. The total rainfall for the month was 11.07 inches, being 8.05 inches above normal. Again, on July 9-10, 4.48 inches of rain fell in 24 hours, while in a similar period toward the close of the month the precipitation amounted to 5 inches.

The result of all this abnormal downpour was that the water at the head of the estuary of Newport River was so freshened that the catfish, especially males with eggs, were driven out of the deep holes along the mud flats at the Narrows and dispersed in the lower and broader reaches of the estuary where it was exceedingly difficult to find them. Thus it came about that the first lot of eggs was not obtained until June 11, the second lot on June 15, and the third and last on July 7. Consequently, the batch of eggs gotten on the first of these dates was far too old to furnish the early stages so earnestly desired, since, by reason of a grant[1] from the Carnegie Institution of Washington, an artist was at Beaufort to draw figures to illustrate the embryology of the fish.

Again in 1912, the search for the Gaff-topsail was greatly hampered by heavy downpours. On May 22 (the day of my arrival at the laboratory) the rainfall was 1.31 inches, and the precipitation from May 6-22, inclusive, was 7.51 inches. This so freshened the estuary of Newport River that the catfish were driven into the lower harbor, and possibly into the ocean. At least none were taken by any drag-net fishermen visited in Newport River, while the menhaden fishermen reported the taking "outside" of considerable numbers—more than usual.

[1]Figures 20, 22 and 28, reproduced in this paper, were drawn under this grant by Mr. E. A. Morrison. The photographs were all made by the author.

Effects of Cold Weather.

In 1911, more strenuous efforts than ever were made to obtain the early eggs. Having heretofore always reached Beaufort after the beginning of the breeding season, I made two trips this year. It should be noted, however, that the spring of 1911 was a late and cold one, extending well into May. There was a light frost in Beaufort on May 8, while toward the 20th it turned suddenly quite warm. The cold weather greatly delayed the breeding season, while it was greatly accelerated beyond the normal when the warm weather came.

On the first trip the laboratory was reached on May 13. On that day, and on the 15th, trips were made to our favorite fishing grounds. Here great numbers of catfish were taken, mainly large Gaff-topsails with enormous ovaries distended with many large eggs. While their bellies were tremendously swollen, their genital orifices were but little reddened, and no eggs could be obtained though vigorous efforts were made to spawn them.

The males, though smaller than the females, were adult, but from none could milt be obtained. None of the males of the first day's catch had "double chins" indicative of a readiness to receive eggs. However, those of the second day's collecting did have the depressed hyoid region, the throat enlargement, but none carried eggs nor could milt be obtained from any.

On the trip of May 18, not a single *Felichthys* was taken. Evidently it was too early, the ripening of eggs and sperms having been greatly retarded by the cold weather. It was necessary for me now to return to my college duties, but on May 20 Mr. Henry D. Aller, Director of the Laboratory, seined for me, but without getting a single cat.

On May 25, I returned to Beaufort and personally supervised another seining, from which were obtained the youngest lot of eggs but one ever gotten during the whole of this research. These eggs had on them blastoderms with forming embryos, but neither these nor any others ever taken showed the coveted segmentation stages. Further seinings brought in only older eggs, and failure and disappointment were the result of this expenditure of time and money.

Difficulties Due to Inexplicable Causes.

The most disheartening failures of all during this collecting work were those for which no cause could be assigned, for neither rain nor cold weather interfered. At various times during all these six years' work, but especially during the latter half of the season of 1910, trip after trip was made to all our hauling grounds, where in times past boatloads of catfish had been taken, but all were "water hauls," few fish and *no* eggs being taken. At one period some six or eight trips, covering two weeks, did not bring in a single egg. To make these trips, it was necessary to leave the laboratory from 3 a. m. to 7 a. m., in order to reach the seining ground at or before low water.

In the meantime many fishermen were visited. Some of these used seines 1,200 feet long and drifted over a mile of river. They caught few small catfish or none at all, and none carried eggs. A few undersized females had in their stomachs small gray holothurians, which are to be found "outside" only, and hence, it seems to be a possible conclusion that for some unknown reason the catfish had left the brackish river for the saltier ocean.

THE NATURAL HISTORY OF *FELICHTHYS FELIS*.

Description of the Gaff-topsail.

Felichthys felis, (*felis,* cat; *ichthys,* fish), whose portrait forms the frontispiece of this paper, is one of the two kinds of sea catfish found at Beaufort, the other being the much smaller *Galeichthys milberti* previously referred to. The body is elongated, but, as figure 22 shows, very large in the head region, the greatest depth being at the anterior edge of the first dorsal fin. The nostril is double. The eye, which has a vertical pupil, surrounded by a red iris, is placed low on the side of the head and just above the insertion of the maxillary barbel. This latter is flat and very long, reaching almost to the anterior base of the pelvic fin. The pectoral and dorsal spines are continued in long filaments, and these, together with the long, flat maxillary barbels, are such marked features as to make it impossible to confuse the Gaff-topsail with any other catfish found in the salt or

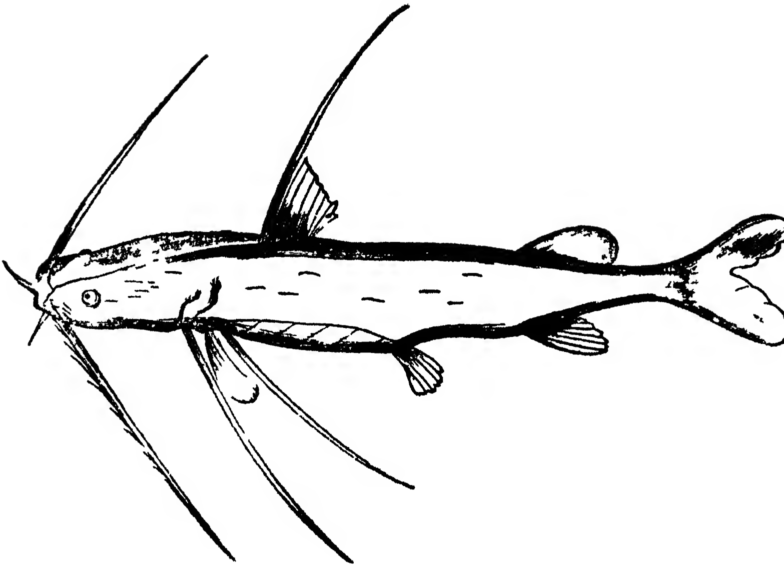


FIG. 24. MARCGRAVE'S GAFF-TOPSAIL
The earliest known figure of this fish (1648)

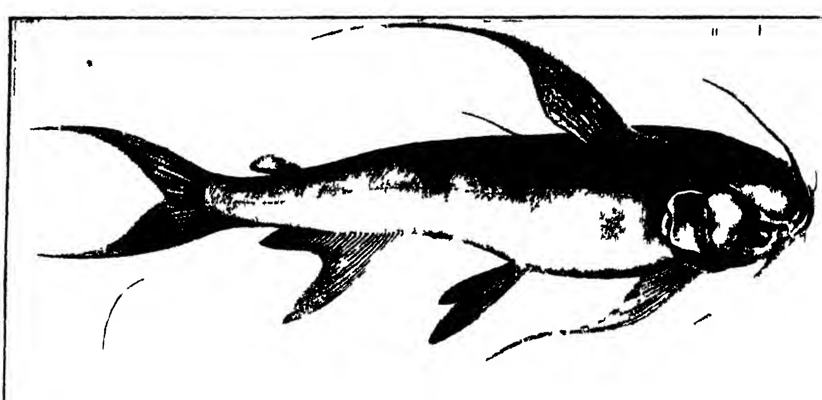


FIG. 25. BLOCH'S FIGURE OF THE GAFF-TOPSAIL (1794)

fresh waters of the United States. The caudal fin is large and deeply forked, the upper lobe being slightly the larger. The color of the fish is a beautiful silvery blue, darker above and lighter below, best seen in lateral view. The fins, especially those on the ventral part of the body, show a reddish tinge as first noted by Mitchill (1815).

History of the Fish.

The discoverer of our fish seems to have been George Marcgrave, in whose Natural History of Brazil (1648) there is figured and described a catfish with flat barbels and long filaments to dorsal and pectorals which is apparently the fish under consideration. Figure 24 is a photographic copy of Marcgrave's figure. This figure, as I have shown elsewhere (Gudger, 1912), was probably painted by Marcgrave himself while in Brazil sometime between 1638 and 1644. It has suffered many things at the hand of the engraver, who seems to have been one De Bray.

His description may be translated: "This Bagre, though of another kind, is in size and shape like the preceding; but it has a beard made of four ray-like barbels, two of which are eight digits long and wide like straps, and two are short ones. To the dorsal fin there is [attached] a similar strap nine digits long, and behind the gills barbels of the same kind. The other [fins] are similar to those of the preceding fish."

Attention is called to the four barbels, the two maxillary ones being long and flat or strap-shaped; and to the strap-shaped (*ligula*) dorsal and pectoral filaments. Another interesting point is to be found in the rays of the dorsal fin. While Marcgrave in 1644 knew nothing of the use of fin rays in distinguishing the genera and species of fishes, he has portrayed his fish with one spinous and seven soft rays in its dorsal fin, the correct number.

Marcgrave's figure and description have been copied by a large number of the old writers. Without going into details there may be named: Piso (1658), Willughby (1686), Ruysch (1718), Johnston (1758), and Bonnaterre (1788). However, that greatest ichthyologist of them all, Marcus Elieser Bloch, in 1794 figured and described a sea catfish from Surinam which

he says is identical with Marcgrave's. Figure 25 here is a photograph of Bloch's fish. He notes that the nostrils are double, that the oblong eyes with black pupils and red irises are near the angle of the mouth. His figure shows four barbels, the two maxillaries being long and flat; and also the long filaments to dorsal and pectoral fins.

Doubt has been expressed as to the correctness of Bloch's identification, but the Eigenmanns in their great monograph on South American catfishes (1890) have identified Bloch's sea catfish with the Gaff-topsail.

Bloch's description gives the fin rays as follows: dorsal, I-8; pectoral, I-12; pelvic, 8; anal, 24. His figure has 26 rays in the anal, but he notes that Gronow counted 23 in the anal of another specimen; it also has I-7 in the dorsal which is correct, though his description says I-8; the figure likewise has 8 rays in the pelvic whereas the true number is 6. However, Bloch in 1794 may be forgiven for a miscount of the fin rays in his figure when Jordan and Evermann (1900) in their figure 52, plate XXIII, have the dorsal fin I-6, and anal 22.

The earliest American describer of the Gaff-topsail was Mitchill in 1815, who took it in the waters of New York. Indeed he definitely gave this fish a place in zoological literature by his splendid description which, however, need not be repeated here. The name *Felichthys felis*, by which the Gaff-topsail is known today, was assigned by Jordan and Evermann in 1900.

HABITAT.

This fish is a sub-tropical form ranging as far north as Cape Cod, but is especially common along the South Atlantic and Gulf Coasts where it is abundant in brackish waters, for which it seems to have a predilection. Bloch as early as 1794 noted that, "This fish (the saltwater katfish) is found not only in Brasil but also in the great rivers of North America." By this he probably meant in the estuary mouths of these rivers which are brackish. The Eigenmanns note (1890) that it is found along the Atlantic coast of America from Cape Cod to Rio de Janeiro.

The earliest account given of the occurrence of catfish in North Carolina coastal waters is found in Thomas Ash's "Caro-

lina," published at London in 1682. The reference to seamen indicates that the fish in question was a marine form, and, since (as will be shown later) the Gaff-topsail is the more abundant of the two marine Siluroids on our coast, we may conclude it to be Ash's fish. "—— Cat-fish, whose head and glaring eyes resemble a Cat; it's esteem'd a very good fish, it hath a sharp thorny Bone on its Back, which strikes at such as endeavor to take it; which by seamen is held venemous."

Again, John Lawson says (1714), "Catfish are round, blackish fish with a Great Flat Head, a wide mouth, and no scales. They sometimes resemble Eels in taste. Both this sort and another that frequents the salt water, are very plentiful." The "another sort that frequents salt water" was in all probability the Gaff-topsail. Brickell (1737), whose data seems largely to have been taken from Lawson, does little else than repeat the statements above given.

The first definite record of the occurrence of the Siluroid fish known as the Gaff-topsail in North Carolina waters was made by Yarrow in 1877. Since his day the fish has been well known and often recorded.

At Beaufort *Felichthys* is taken everywhere in the "rivers," which are really brackish estuaries. My best catches have been made at the very head of Newport estuary, within one mile of the limit of tide water, where at dead low water the density was 1.007.

It is very abundant on both coasts of Florida; in the Indian River so much so as to be a great nuisance to the fishermen. It is also abundant in all the sound-like lagoons and the estuarine river mouths opening into the Gulf of Mexico.

H. M. Smith (1907) says that the smaller relative of the Gaff-topsail, *Galeichthys* (weasel-fish) *milberti*, is the most abundant of the sea catfish at Beaufort, but I have not found it so in my many years of seining there. The Gaff-topsail is found in large schools, and I have often taken 100 or more at a haul, while my fishermen on one occasion caught a wagon-load, estimated at over 500, ranging from 20 to 25 inches in length. On the other hand I have never taken more than a half dozen at a time of the small-mouthed catfish. It seems to be a shy and possibly a rather solitary fish.

Swimming Habits.

The Gaff-topsail is a bottom liver, and generally not a very rapid swimmer. The strong tail and deeply forked caudal fin might lead one to think to the contrary, but, if the fish is viewed from above (Fig. 22), it is readily seen that the enormous head parts would render it impracticable if not impossible for the fish to get up much speed.

Although a bottom swimmer, nevertheless as the net comes in, the Gaff-topsail has the interesting habit of swimming near the surface of the water with the dorsal fin, or at any rate the filament, projecting above the water. This habit of carrying the dorsal fin and filament in an elevated position gives it its name, Gaff-topsail. DeKay as early as 1842 made note of this peculiar swimming habit. In Newport River at dead low water, when the fish, driven off the mud flats as the water lowers, collect in deep holes, this same habit may be noticed.

Furthermore, for two weeks in the summer of 1910 I kept a 12-inch *Felichthys* in a 4 by 6 foot wooden tank in the laboratory at Beaufort, and during this time it persisted in swimming at the surface of the water with its dorsal filament carried high out of water. At the same time two *Galeichthys* in the same tank as persistently swam at the bottom 6-8 inches below. Gaff-topsail larvae also show a marked tendency to swim at or near the surface of the water of their aquaria. Even more marked is their habit of "hanging" motionless at the surface, much as a frog does.

Behavior when Caught in a Net.

When caught in a seine, the Gaff-topsail has the very annoying habit of rolling itself up and very effectively entangling its dorsal and pectoral spines in the meshes. So firmly imbedded does it sometimes become that it is necessary to break its spines or to cut the net to get rid of it.

It is also a great annoyance to the fishermen in another way. All fish give off a slimy mucus which is very destructive to nets, causing them to rot rapidly, but of all fish known to me the Gaff-topsail, when caught, gives off not only the most slime, but

the most tenacious. Only repeated washings and rubbings will take it off the hands, and it is almost impossible to get it off the nets. Fishing for and handling this catfish is a very nasty matter.

Defensive Habits.

So far as I have been able to ascertain the Gaff-topsail has no offensive habits. Twelve and fifteen-inch specimens kept in tanks with various other and smaller fishes showed no tendency to molest these latter. It is true that *Felichthys* is sometimes found with fish in its stomach, but it is not impossible that these were dead or at any rate disabled ones which were not able to escape the relatively slow moving catfish. Certain it is, as will be shown in the next section, that the food of this species is mainly crustacean.

However, weapons of defense are present in the shape of dorsal and pectoral spines and are capably used. If the fish is caught and held by the tail it will swing violently and convulsively to the right and left almost through an arc of 180°, endeavoring to strike with its pectoral spines. If picked up incautiously it will almost surely wound one. The only safe way to grasp it is across the back of the head in front of the dorsal spine, the thumb on one side and the fingers on the other behind the pectoral fins. Held firmly thus (see Fig. 21), it is almost incapable of inflicting a wound. Such wounds, while quite painful, are not especially dangerous, though bacteria carried in with the slime may set up an inflammation and the slime itself may possibly be toxic.

These points were covered by Thomas Ash, two and one-third centuries ago. Writing in 1682, he says of a marine catfish on the coast of North Carolina (for reasons given before, presumably the Gaff-topsail): ". . . . it hath a sharp thorny Bone on its Back, which strikes at such as endeavor to take it; which by Seamen is held venemous; yet, I saw one of our Seamen, the back of whose Hand was pierced with it, yet no poysonous Symptoms of Inflammation or Rancor appeared on the Wound, which quickly healed, that I concluded it was either false, or that of this Fish there were more kinds than one."

Food and Feeding.

The Gaff-topsail is an omnivorous feeder, almost anything being meat that comes to its mouth, whether fish or crab or worm. It seems to affect mud flats and after them submerged sand flats as feeding grounds. The water in the Beaufort region, where the sea cat-fish is found, is too muddy for any observations to be made on the feeding habits, but if one may judge of these by analogy after observing the habits of the young (4 to 6 inches long) in a large aquarium, it probably feeds by swimming a few inches above the bottom with its long barbels, tactile organs, just touching the surface of the mud. Whenever these touch anything edible, there is a quick turn, a sudden opening of the cavernous mouth and it is gone. I have often experimented with the young, and have found their barbels exceedingly sensitive to bits of oyster dropped into the aquarium. I have seen the little fish thus arrested, stop in full flight and even turn a somersault in its eagerness to get at the oyster. The fish, of course, would readily perceive moving objects and if these were edible, would snap them up. The feeding described above is more that of a scavenger.

The food of the adult is—anything edible. I have on dissection found the stomach filled with fish, worms, crabs. The latter, however, is its staple food, and I have taken from the stomach blue crabs so large that it was difficult to see how they could have been taken into the mouth and down the oesophagus. Autopsy has revealed the presence of ascidians, and, during one summer, certain small gray holothurians as noted above (page 138). H. M. Smith, (1907), notes similar feeding habits and food for the smaller ocean catfish, *Galeichthys milberti*, at Beaufort.

Before leaving this subject it may be noticed that in Florida this and the other marine catfish are accused of feeding on human feces. I have had a very detailed account of this from a man who is absolutely reliable, and his account has been corroborated by a scientific friend who has personally seen the fish thus engaged.

Parasites.

As might be expected from its omnivorous feeding habits, the Gaff-topsail harbors a considerable number of worm parasites. However, as the greater number of my autopsies have been performed at the fishing ground with other points in view and while greatly pressed for time, my notes merely record the finding of worms in the stomach. Further, however, it is interesting to note that another investigator, working at Beaufort on internal protozoan parasites, has found in the intestine of our fish considerable numbers of a large potato-shaped ameba having remarkably clear protoplasm and a rapid rolling motion. This and other results have not yet been published.

Use as Food.

The value of the Gaff-topsail as a food fish is, irrespective of other points, considerably diminished by the large size of its head and by the bony cuirass extending back to the origin of the first dorsal. Nevertheless, it has been, and is used as food. Bloch, (1794), says that it is eaten, but that its flesh is not especially palatable. Ash, (1682), remarks of the marine catfish that: ". . . . it's estem'd a very good Fish." The older American ichthyologists thought highly of it as a food fish. Thus Mitchill, (1815), says, "It is an exquisite fish for eating." While De Kay, (1842), writes: "Its flesh has been represented to me by those who have eaten it as having an exquisite flavor." But Jordan, (1884), while remarking that its flesh is palatable, says that it rarely is saved for food, for the most part being thrown away.

Various authors, Jordan and Gilbert (1883), Henshall (1891, 1895), Evermann (1899), Gregg (1902), and others, writing of this fish in our southern waters, say that by reason of the abundance of other and far better fish it is rarely eaten, save by negroes. I never knew the fish to be eaten at Beaufort, nor was there any demand for it for export save in one season. There was a considerable shortage of fish in 1908 and a New Bern fish dealer, who had a "buy boat" anchored in Newport River, bought Gaff-topsails along with other common (non-choice) fish to sell

to the negroes of that town. I have eaten its flesh, in order to be able to report on it, and have found it not unpalatable, but not particularly appetizing. Perhaps, however, it was not well prepared.

Sounds Made by the Fish.

Felichthys felis makes two distinct sounds, one a croaking and the other a rasping sound. The first is the more common and is produced by the swim bladder. If the fish be grasped back of the pectorals, distinct pulsations may be felt with every croak. These are very apparent in a fresh and vigorous fish, especially if it shows signs of anger. Larvae also croak and by holding them in the fingers it will be noted that, as in the adults, pulsations may be felt in the body wall.

The rasping sound made by the Gaff-topsail was first thought to be due to the fish rubbing its superior and inferior pharyngeals together. However, it was soon noticed that the grating or rasping sound was accompanied by a spamodic jerk of the pectoral spines, and that if these were held immovable no rasping sound could be perceived although the croaking continued, the gritting noise beginning again when the spines were released. So it seems that these sounds are made by the spines as they rotate in their sockets.

On one occasion, after some resistance on her part, I took a large active female cat from the water and laid her down in the dip net on a small pile of oyster shells, whereupon she made a spitting noise for all the world like an angry tabby cat. I am not sure how it was done, but it was possibly a combination of the two sounds previously described, and the pile of oyster shells may have acted as a resonator aiding in combining the two sounds. This was the only occasion on which this peculiar sound was noticed.

Size of Breeding Females.

It will be of interest briefly to consider the size of breeding fish, and first of the females. In fish generally these run larger than the males, and in our catfish this is especially true, due largely to the enormous ovaries filled with huge eggs ranging up to 25 mm. in diameter.

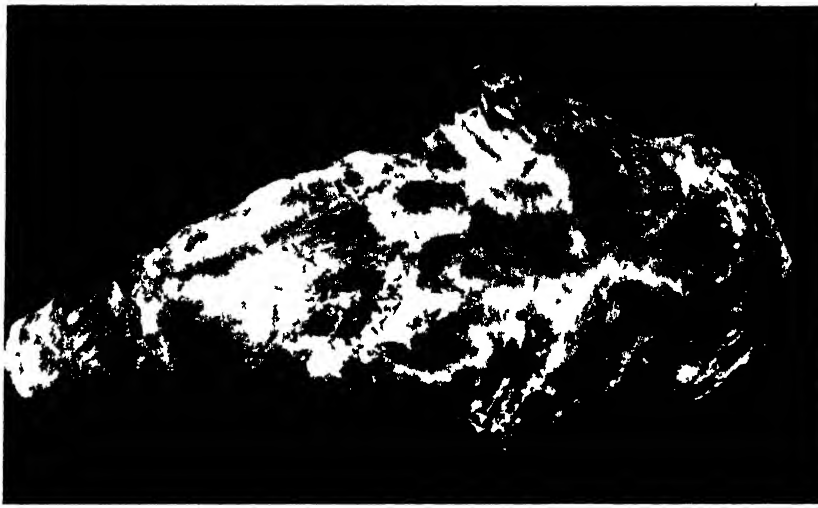


FIG 26 CEMENT CAST OF THE MOUTH OF THE MALE FISH CARRYING [illegible] EGGS
Dorsal view

FIG 27 CEMENT CAST OF MOUTH
Lateral view of Fig 26

The fish taken on May 13 and 15, 1911, are quite typical of breeding females. These had not spawned their eggs and hence had enormous bellies. The largest, taken May 15, measured: 19½ inches, 1; 20 inches, 2; 22½ inches (15 inches in girth), 2; 23 inches, 1; 23½ inches (14 inches in girth), 1; 24½ inches, 1; 25 inches, 1. This last was the most enormous catfish I ever have seen. She measured 19 inches in circumference just back of the dorsal fin, the filament only of which (whence the name Gaff-topsail as noted above) was 3¾ inches long. She had, however, not reached her maximum size for her eggs were not ripe—they could not be spawned.

SIZE OF THE INCUBATING MALES.

This can best be set forth by giving the sizes of 32 egg-carriers measured on the initial trip taken in this research, June 22, 1907. It will be noted that their sizes run very uniform, but that they are markedly smaller than the females. On this day there were measured: 1, 15¾ inches over all; 4, 17½ inches; 9, 18 inches; 3, 18¼; 7, 18½; 2, 18¾; 1, 19; 1, 19¾; 1, 20; 1, 20½; 2, 21: 32 in all. Of these 32, 23 range from 17½ to 18½ inches; and generally speaking later observations confirm these figures as being the average.

HOW THE EGGS ARE CARRIED.

These breeding males, as previously noted, carry the eggs loosely in the mouth, the gill-covers being widened outwardly and the hyoid distended downward to make the "double chin" previously referred to. In this way the cavity of the mouth is enlarged and its capacity increased. As may be seen from figure 22, which is a pen and ink sketch of a 17½ inch breeding male, the Gaff-topsail, like most siluroid fishes, is largely head, and the head is mainly mouth. Figure 21 shows the mouth distended in the hyoid region to accommodate the eggs.

Size of Mouth Cavity.

A number of casts were made of the mouths of fish carrying large numbers of eggs, but of them only the largest will be considered here. This was of a 22-inch male burdened with fifty-five eggs, the largest number ever obtained from any Gaff-topsail in the course of this work. This fish was carried to the laboratory, seven miles away, that the capacity of its enormous "Keim-höhle" might be made. However, there was but a small quantity of plaster of Paris in the laboratory and *none* in Beaufort. In this predicament, Director Aller came to the rescue with the suggestion that cement be used, there being a barrel at hand. So a tolerably thick grout was made and the mouth filled with it, a towel being wrapped around the gills to prevent the escape of the cement before it had hardened. The head was then cut off, put out in a cedar thicket, where covered with a box it was left until the ants had eaten off the flesh. Later it was cleaned, shellacked, and photographed. Figures 26 and 27 are dorsal and lateral, views of this huge cast. The volume of this cast, up to the insinking in the oesophageal region, is 580 cc.

Size and Structure of the Skull.

In intimate connection with the size of the mouth is the matter of the magnitude of the skull. Reference to figures 20 and 22 shows that the head makes up a large part of the body, about one-quarter of the length and possibly an equal part of the bulk. The buccal cavity, as has been shown in the preceding section, is enormous. In order that the reader may get a clearer idea of what gives it this great size, two views of the skull are given. Figure 28 is Mr. Morrison's drawing of the dorsal surface, while figure 29 is a photograph of the ventral surface of the same skull. The buccal cavity extends the whole length of the under surface of the skull, the hinder part, the beginning of the oesophagus, being formed under the coalesced vertebrae.

Since such would be apart from the purpose of this paper, no attempt will here be made to work out the osteology of this very interesting skull. However, attention may be called to its armor-clad dorsal surface. This will explain why so much

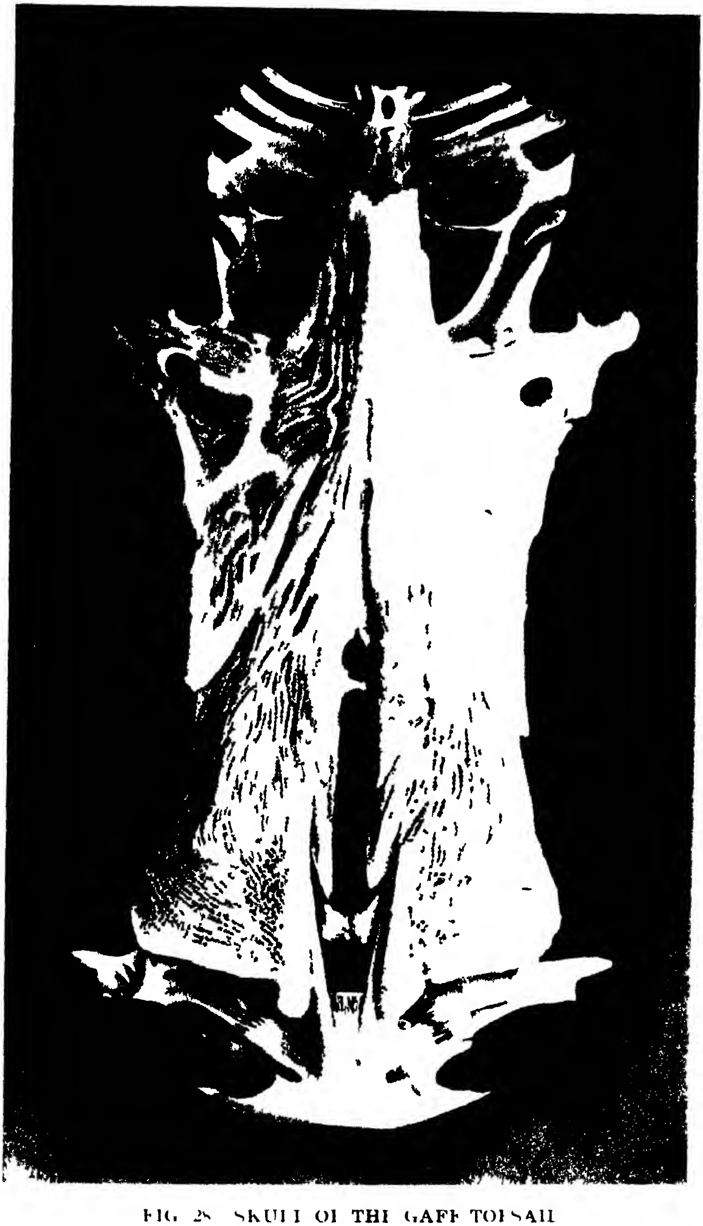


FIG. 28. SKULL OF THE GAFF TOPSAIL
Dorsal view showing the fontanelle

clubbing on the head is required to subdue an active catfish. There is, however, one easy method of quickly and comparatively easily killing a catfish. This is by inserting a knife blade through the slit in the anterior median line in the bony armor. Through this the brain is easily reached. This open space in the roof of the brain is called a fontanelle. In the higher bony fishes it is closed, and its presence here is an evidence of the lowly position of the catfish in the class Pisces. It is an inheritance from its shark ancestor, which had a very marked fontanelle in the corresponding region of its skull.

The only person, who, so far as has been found, seems ever to have noticed this structure in the skull of the catfish and consequently this method of killing it, was John Luccock. Luccock made a journey in 1808 to Rio de Janeiro and the River Plate, and twelve years later published a very interesting account of his travels which contains many valuable natural history notes. In speaking of the Bagre caught in the La Plata off Buenos Aires, he says: "It lives long out of water and is with difficulty killed by blows. I observed in the plate of the skull, between the eyes, a small aperture, covered with a thin whitish membrane, and imagined that through this, it might be killed by touching the brain. We accordingly introduced a filament taken from one of the bass cables, which produced an immediate paralysis and the fish died without further suffering."

Turning to the ventral surface of the skull of *Felichthys* we find some equally interesting structures. In the posterior region are the large round paired bullae containing the ear stones. Ventral and posterior to these we have a curious bony formation very like a crucifix, the two little semi-circular bones behind (above) it looking somewhat like a halo. I have the indefinite recollection of having somewhere read of the feeling of semi-veneration paid to the catfish skull showing these structures by the superstitious inhabitants of the Guianas and the neighboring islands but I have been able to lay hands on but one reference.

The Beebes in their charming book, "Our Search for a Wilderness", (1910) say that, while their vessel was anchored in one of the mouths of the Orinoco: "At the bottom, our hooks would

be taken by great fierce-whiskered cats, bedecked with long streamers, which gave no end of trouble before they were quieted. They were pale yellow, and the head and back were encased in bone; Maestro the cook called them the Crucifix fish, and later showed us why. On the under surface of the bony armor is a large cross with a halo about it just above the arms. The crew never caught one of these fish without making the sign of the cross in their right palm".

The Beebes give a photographic reproduction of "the crucifix in the catfish", but their figure seems to have been made from a skull that had suffered considerable erosion. It does not have the sharpness and clearness of detail found in figure 29.

Size of Eggs and Number Carried.

The ripe eggs vary in size as is to be expected, running from 15-25 mm., but the average diameter is 19-20 mm.. The smallest number of eggs found in the mouth of any gestating male was two. Two fish were found, 13 and 15½ inches long over all, each with two eggs. Once, it is true, a large male was found carrying only one egg, but from the great size of his buccal cavity there is good reason to believe that other eggs had been thrown out in the process of capture. This I have known the Gaff-topsail to do. Large numbers of eggs are by no means unusual; a dozen fish have been taken with eggs in the thirty's; forty-five eggs have been taken twice; fifty were obtained from a 22-inch male; and greatest of all fifty-five from another fish of the same size.

Attempts to Hatch the Eggs Artificially and the Difficulties Met With.

Early in the course of this investigation it was seen that it would be necessary to carry these eggs by artificial means to the point of hatching and beyond, if an embryological series was to be obtained. However, it seemed doubtful if eggs accustomed to such a highly specialized brooding chamber could possibly be carried on to hatching in open jars of running sea-water.

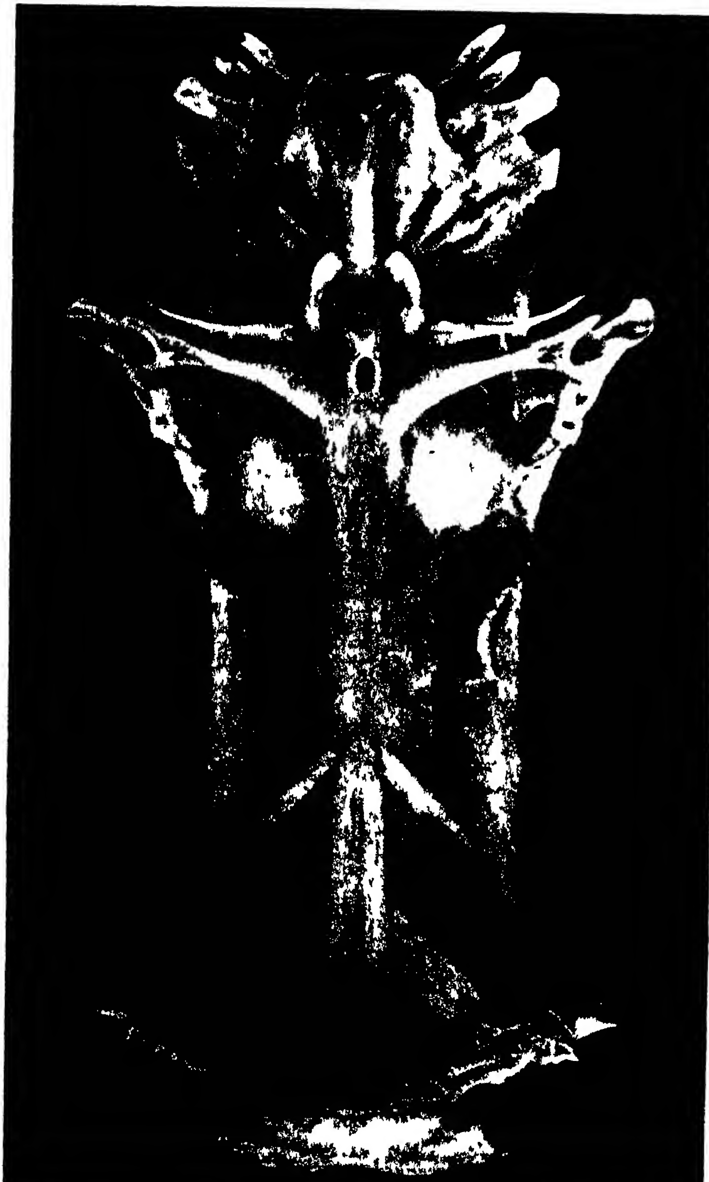


FIG 29 VENTRAL SURFACE OF SKULL

Showing the 'Crucifix' in the Catfish
Photograph of same skull as Fig 28

Unfortunately it was never found possible to bring incubating males to the laboratory, for the fish either died or at best became sick and spat out their eggs. The eggs however could readily be brought in in pails of water renewed at intervals.

But for all this great difficulty was experienced in keeping these eggs alive. At first they were kept in shallow glass aquaria under running salt water, but the fine sediment from the water so thickly covered their shells that the supply of oxygen was to no inconsiderable degree cut off. That this was not the only cause of their "going bad" was, however, afterwards ascertained.

To remedy this, some of the eggs were put in filtered sea-water with *Ulva* and placed near a window but not in direct sunlight. Though some died, others did fairly well for a while. The greater number, however, were put in baskets of a coarse-meshed galvanized wire netting and hung in aquaria 9 inches deep under running salt-water—the idea of course being that the greater part of the sediment would fall through to the bottom. These baskets were hung with copper wire covered with thread and erroneously supposed to be paraffined. Possibly this combination made a weak electrolytic apparatus. At any rate, on the day following their suspension thirty-nine dead eggs were taken from the baskets. The baskets were then suspended by zinc-coated wires, but the mesh being rather large, the heavy eggs settled down in it in such a way as to cause congestion in the yolk circulation and finally death.

After the death of all the eggs, as noted in the preceding paragraph, another trip was made and another lot of eggs in fine condition was brought in. Each had an embryo on the top nearly ready to burst the shell. Each little fish rested in a groove in the yolk, the head lying flat with both eyes above the groove. The tail of each was bent, the caudal fin covering one eye and reaching to the edge of the other. Here again see figure 23.

The eggs continuing to die daily, in seeking to remove all possible causes, it was thought that the density or saltness of the water might be too great. This at the laboratory averaged 1.021, while at the Narrows of Newport River, where the fish were caught, it was at the surface 1.007. To obviate this possible cause a number of eggs were put into filtered sea-water

diluted with filtered rain-water to a density of 1.016 and were placed under running water of the same kind carried over by a siphon. These eggs all died, possibly because the flow of the siphon was insufficient to aerate the water in which they were placed. Presently but one egg remained. The larva on this had burst its tough shell on the dorsal side, and through the slit had thrust its head and the anterior part of the body. With its projecting eyes, black with a golden ring, and its head parts faintly stippled in black, it presented a striking and beautiful appearance. Fig. 30, A and B, from photographs made on this day, give some idea of the dorsal and ventral surfaces of this egg; only colored drawings could do it justice. Probably as a result of the handling incidental to the photographing of this egg, is was found dead the next morning.

All other methods having failed to bring about the hatching of these eggs, it was determined to try the hatching jar devised by former Commissioner of Fisheries MacDonald and named after him. In this apparatus water is admitted to the bowl-shaped bottom of a tall glass jar, whence it rises up through the eggs and escapes by means of a pipe at the top. The purpose is to keep the eggs continually in motion and to carry off all sediment, bacteria, and mold spores by the escape pipe at the top. With the catfish eggs it was hoped that the current of water would be sufficiently strong to keep the eggs agitated, to lift them up enough to prevent the congestion of the ventral yolk-sac circulation consequent upon the considerable weight of yolk plus embryo. However, the outcome was only partially successful, for even in the hatching jars the mortality was very great.

On July 7, 1908, a trip to the Narrows was made in the hope that hatching eggs might be gotten. In this we were successful for two cats were taken. One, 17¼ inches long, carried thirty-six eggs. The little cat on one of these eggs had burst its prison and had thrust its head out of the rent in its shell as shown in figure 30 and the others were about ready to do so. The other male carried in his mouth six larvae 53-55 mm. long over all, sitting on yolk sacks so heavy that they could not yet lift them. Here again see figure 31. This would seem to fix the first week in July as the approximate hatching time.

A B

FIG 30—A & B. A LITTLE GAFF-TOPSAIL THAT HAS JUST BURST THE SHELL

A—Dorsal view. B—Ventral view.

From an instantaneous photograph

FIG. 31. LARVAE OF THE GAFF-TOPSAIL CATFISH

From an instantaneous photograph of the little catfish skating on their yolk-sacks at the bottom of an aquarium.

Great difficulty was experienced in hatching these eggs. Some died with congested yolk circulations as described above for the previous year, others gradually grew pale and finally died without any definite cause being found. And now there was developed a new trouble which threatened to carry off all the remainder at hatching time. Their shells seemed to grow rotten so that the fishlets by vigorous twistings could burst them at one place or another. When this took place in what may be called the anterior region, so that the head could be thrust forth, all was well. For this see figure 30. But when as more commonly happened, the shell burst elsewhere and the compressed yolk pushed out the investing wall with its plexus of blood vessels forming a hernia, death shortly ensued from strangulation of the circulation unless the trouble was relieved at once. At this stage in the history of the little cats, life was conserved only by constant vigilance. I kept watch by day and until 11 o'clock at night and the night fireman thereafter; and, whenever a "herniated" egg was discovered, the shell was torn partly or completely off the egg and the hernia pressed back into place with the smooth handle of a scalpel. This was a rather rest-disturbing matter since I was frequently awakened three or four times in one night. But the operation was for the most part successful since some 75 per cent. of the young so treated recovered. The majority of deaths in these "hulled" eggs resulted from the congestion of the ventral yolk circulation brought about by the weight of the fish and yolk or by the continued wriggling of the fishlets. Those from which the shells had been removed suffered especially, since their yolks flattened down greatly, while those whose shells were merely torn open, but not removed, suffered far less since their yolks were partially supported. All were put on beds of cotton wool at the bottoms of aquaria under jets of sea-water.

During the season of 1909 in endeavoring to hatch the eggs, the experience of the past seasons was repeated. The eggs went forward very well till they neared the time when they might be expected to hatch, then they died by fives and tens and twenties. An interesting phenomenon may here be noted which may offer a possible explanation for some of these deaths. On July 1 there was noticed inside the shell of an egg a small mass of greenish-yellow matter looking much like the fecal matter given

off by a young baby and noted as such at the time. Further an embryo at the time of hatching or a few minutes thereafter had hanging from its vent a string of fecal matter. A third egg on the same day exhibited a similar state of affairs. All this leads one to question whether it may not be that some of these eggs which die just at the time of hatching are poisoned by fecal stuff given off by the embryos and confined within the egg shell.

The embryos from the paternal mouth, which were just ready to hatch, had far less difficulty in ridding themselves of their shells than the ones brought up in MacDonald hatching jars. And while it is probable that there is some mortality among the eggs incubated in the mouth of the father, there is no doubt that it is nothing like so great as that among eggs hatched artificially.

Just as the percentage of fish hatched in the paternal mouth is greater than that of those brought up in a hatching jar, so is it probable that the young incubated therein mature earlier than in the jars. This seems to be confirmed by this fact. On July 20, my fishermen, men whom I know well and in whom I have great confidence, brought in a little cat about four inches long taken from the mouth of a 20-inch male. This little fish was grown in the sense that its body walls had completely coalesced over the yolk. The men reported that they saw several little ones in their net. These they tried to catch, but they escaped through the meshes of the seine, the large fish, however, retained one in his mouth. This young one gave much trouble by jumping out of the bucket of water into the bottom of the boat, and finally escaped by jumping overboard as it was being handed to me at the wharf.

In contradistinction to the early hatching noted above in the mouth of the father, of the larvae in captivity, taken on July 7, 1908, the older ones did not close over their yolk sacs until August 5-8, while the corresponding dates for the younger captives was August 15-17. Making all allowance for difference in time of beginning incubation, the two or three weeks' interval separ-

ating the periods of yolk disappearance in the two sets of larvae is too long to be accounted for satisfactorily save on the ground that the young in the mouth of the paterfamilias develop more rapidly. This must be due to the fact that they feed while therein.

How the Embryological Series Was Obtained.

For six years (1907-1912) the search for the fish and its eggs went on, and with few successes and many defeats the series of eggs was pushed both backwards and forwards. By fitting in one egg here and another there and a third elsewhere, the series is now complete from invagination to the free swimming young in which the walls of the belly have closed over the diminished yolk sac and have coalesced into a raphe on the median line. The inability to obtain the segmentation stages is a great disappointment, for they only are lacking for the complete embryology, but, since the most strenuous efforts continued for six years have failed to obtain them, I have come to the reluctant conclusion that chance in the case of this fish will play more part in the collecting of eggs and embryos than any amount of hard and long continued effort.

Conclusion.

How the eggs are extruded, fertilized, and transferred is not known, but when these processes are effected the male incubates the eggs in his mouth not only until they are hatched by the bursting of the shell, but until the yolk has been absorbed and the young are able to take care of themselves. The largest number taken from the mouth of one male was fifty-five. A cement cast of his mouth had a volume of 580 cc. The volume of an average sized egg is 3.75 cc., of the fifty-five eggs 206.3, add 25 per cent for interstices; total space occupied by the fifty-five eggs equals 258 cc. This fish was 22 inches long and of average size. The eggs average 19-20 mm. in diameter, and the young fish at the end of the period of incubation are 85-100 mm. long. The length of this period can not be stated definitely, since it has been found to be impossible artificially to carry the

eggs and embryos to the stage of the free-swimming young. However, it is probably about seventy days. During all this time the paternal nurse does not seem to feed. The large eggs would, if spawned on sandy or shelly bottoms, be quickly destroyed by crabs or by other fish; if laid on a mud bottom (where the breeding fish are caught) their considerable weight would cause them to sink into and be smothered by the mud. This habit is common in estuarine catfish in all tropical and warm temperate regions. These data are based on six summers' work at the Beaufort laboratory of the United States Bureau of Fisheries, in which time scores of male fish carrying eggs and larvae have been captured and autopsied.

BIBLIOGRAPHY

ASH, THOMAS.
1682 Carolina; or a Description of the Present State of that Country, and the Natural Excellencies thereof, etc., p. 26. London.

BEEBE, MARY B. AND C. WILLIAM.
1910 Our Search for a Wilderness, pp. 13-14, fig. 5. New York.

BLOCH, MARCUS ELIESER.
1794 Naturgeschichte der Ausländische Fische, Achter Theil, p. 26. Berlin.

BOAKE, BANCROFT.
1866 On the Air-Breathing Fish of Ceylon. Journal Ceylon Branch Royal Asiatic Society for 1865-66, pp. 128-142.

BONNATERRE, PIERRE JOSEPH.
1788 Ichthyologie: Tableau Encyclopedique et Methodique des Trois Regnes de la Nature, p. 154. Paris.

BRICKELL, JOHN.
1737 The Natural History of North Carolina. Dublin.

DAY, FRANCIS.
1889 Fauna of British India: Fishes, vol. I, pp. 169-170. London.

DE KAY, JAMES.
1842 Zoology of New York, or the New York Fauna, Part IV, Fishes in Natural History of New York, p. 179.

EIGENMANN, C. H. AND R. S.
1890 A Review of the South American Nematognathi or Catfishes. Occasional Papers California Academy of Science, vol. I, p. 36.

EVERMANN, B. W.
1899 Report on Investigations by the United States Fish Commission in Mississippi, Louisiana and Texas in 1897. Report United States Fish Commission for 1898, pp. 285-310.

EVERMANN, B. W., AND BEAN, B. A.
1898 The Indian River and Its Fishes in The Fisheries of Indian River, Florida. Report United States Fish Commission for 1896, p. 240.

EVERMANN, B. W., AND GOLDSBOROUGH, E. L.
1902 Notes on Some Mexican Fishes. Science, n. s., vol. XV, pp. 746-749.
1902 Report on Fishes Collected in Mexico and Central America. Bulletin United States Fish Commission, vol. XXI for 1901, pp. 140-146.

GUDGER, E. W.
1912 Oral Gestation in the Gaff-topsail Catfish, Felichthys felis. (Abstract). Science, n. s., vol. XXXV, p. 192.
1912 George Marcgrave, the First Student of American Natural History. Popular Science Monthly, pp. 250-274.

GÜNTHER, A. C. L.
1864 Siluroids in Catalogue of Fishes in the British Museum, vol. V, p. 173.
1866 Description of a New Siluroid Fish from Ceylon. Annals and Magazine of Natural History, ser. 3, vol. XVII, pp. 473-474.
1880 An Introduction to the Study of Fishes, p. 160. Edinburgh.

GREGG, W. H.
1902 Where, When, and How to Catch Fish on the East Coast of Florida, New York and Buffalo.

HENSHALL, J. A.
1891 Report upon a Collection of Fishes Made in Southern Florida during 1889. Bulletin United States Fish Commission, vol. IX for 1889, p. 373.
1895 Notes on Fishes Collected in Florida in 1892. Bulletin United States Fish Commission, vol. XIV for 1894, p. 211.

BIBLIOGRAPHY.

JONSTON, JOANNES.
1758 Historia Naturalis Piscibus et Cetis, Libri V, tab. 38, fig. 3.

JORDAN, DAVID STARR.
1884 The Catfish Family in Natural History of Useful Aquatic Animals, Sec. I of The Fisheries and Fishing Industries of the United States, G. Browne Goode, Editor.
1905 A Guide to the Study of Fishes, vol. I, p. 128; vol. II, p. 179. New York.

JORDAN, DAVID STARR, AND EVERMANN, B. W.
1900 The Fishes of North and Middle America, vol. IV, fig. 52, plate XXIII, and p. 3196.
1883 Notes on Fishes Observed about Pensacola Harbor, and Galveston, Texas, etc. Proceedings United States National Museum, vol. V for 1882, p. 245.

JORDAN, DAVID STARR, AND GILBERT, C. H.
1883 Notes on a Collection of Fishes from Charlestown, South Carolina, etc. Proceedings United States National Museum, vol. V for 1882, p. 584.

LAWSON, JOHN.
1714 The History of Carolina: Containing the Exact Description and Natural History of that Country. Reprinted Charlotte, N. C., 1903, p. 94.

LUCCOCK, JOHN.
1820 Notes on Rio de Janeiro and the Southern Parts of Brazil, etc., p. 148. London.

MARCGRAVE, GEORGE.
1648 Historiae Rerum Naturalium Brasiliae (De Piscibus, Liber Quartus), p. 174. In Historia Naturalis Brasiliae by William Piso and George Marcgrave, Amstelodami.

MITCHILL, SAMUEL L.
1815 The Fishes of New York Described and Arranged. Transactions Literary and Philosophical Society of New York, vol. I, pp. 433-434.

PISO, WILLIAM.
1658 De India Utriusque Re Naturali et Medica, p. 64, Amstelodami.

RUYSCH, HENRY.
1718 Historia Naturalis Piscium in Theatrum Universale Animalium, etc., p. 143.

SMITH, HUGH M.
1907 The Fishes of North Carolina. Vol. II of N. C. Geological and Economic Survey, pp. 62-63, Raleigh.

TURNER, WILLIAM.
1867 On a Remarkable Mode of Gestation in an Undescribed Species of Arius. Journal of Anatomy and Physiology, vol. I, pp. 78-82.

WILLUGHBY, FRANCIS.
1686 Ichthyographia. De Historia Piscium, Libri Quatuor, p. 140, Oxonii.

WYMAN, JEFFRIES.
1857 Exhibition of and remarks on Some Fishes of Surinam and on the Conditions under which their Eggs are Developed. Proceedings Boston Society of Natural History, Sept., 1857, pp. 268-269.

YARROW, H. C.
1877 Notes on the Natural History of Fort Macon, North Carolina, and Vicinity. No. 3—Fishes. Proceedings Academy Natural Sciences of Philadelphia, vol. XXIX, p. 216.

ZOOLOGICA
SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBER 6.

MAMMALS OF AUSTRALIA IN THE ZOOLOGICAL PARK

Illustrated with photographs by the Author and Elwin R. Sanborn

By W. H. D. LE SOUEF,
Director Zoological Gardens, Melbourne.
Author "The Animals of Australia," "Wild Life in Australia."

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

JANUARY, 1919

PREFACE

DIRECTOR LE SOUEF AND THE AUSTRALIAN FAUNA.

In length and breadth of departure from the recognized standards of mammalian anatomy and physiology, the mammals of Australia are, per capita, the most odd and remarkable of any continental group. With the exception of the dingo, a few rodents and bats, all those species that do not lay eggs are marsupials, and carry in the abdominal pouch the astoundingly minute newly-born young until it grows to a size fit to take a small place in the outer world. A newly-born kangaroo cannot possibly be appreciated by a stranger until it is seen.

The Australian marsupials display a remarkable line of radiating development that is quite inexplicable to zoologists. This relates to the production of forms within an order, that strikingly parallel in external appearance the characteristic forms of members of various orders of mammals. It would appear as if the scheme of evolution among the Australasian marsupials tended to produce an aggregation of pouched mammals that in form and habits would cover the strange absence of other orders. The Tasmanian "wolf" may be cited as an example and the ant-eating echidna, with its porcupine-like quills, as another. There are carnivorous, fox-like phalangers, marsupial "mice," the wombat—in form and habits like a gigantic woodchuck, and the flying phalanger, which latter animal is precisely like a flying squirrel in form and actions. Yet more remarkable is a marsupial mole.

The New York Zoological Park always has been rather strong in Australian mammals. They are so universally interesting as to be irresistible. Our Australian collection is now very rich. As a contribution to public interest in these strange creatures from the continent wherein Nature has done everything differently, the distinguished Director of the Melbourne Zoological Gardens has been prevailed upon to write a series of short, popular sketches of the Australian species now or recently exhibited here, and illustrate many of them with photographs taken by him in Australia.

Mr. Le Souef is a man of charming personality and successful habit. He visited and lectured in America about eight years ago, and thereby greatly strengthened the bonds of interest between the zoologists of his country and ours. He is the author of books on the wild life of Australia that are at once deeply interesting and thoroughly reliable. The titles of those best

known are "Wild Life in Australia" (London, 1907), and "The Animals of Australia," by A. H. S. Lucas and W. H. Dudley Le Souef (London, 1909).

W. T. HORNADAY.

CONTENTS

FIGURES

Photograph by W H D LeSouef

FIG 32. A TYPICAL FOREST IN THE PROVINCE OF VICTORIA, AUSTRALIA

This home of the beautiful Tree Fern is also the favorite haunt of the now rare Lyre Bird, the Black-Tailed Wallaby, Yellow-Breasted and Rose-Breasted Robins, Giant Kingfisher and Giant Earthworm. "Fern gullies always are delightful places to visit on a hot day"

MAMMALS OF AUSTRALIA IN THE ZOOLOGICAL PARK

By W. H. D. LE SOUEF,

Director Zoological Gardens, Melbourne.

Author "The Animals of Australia," "Wild Life in Australia."

ILLUSTRATED WITH PHOTOGRAPHS BY THE AUTHOR AND ELWIN R. SANBORN.

INTRODUCTION.

Australia is a large country, approximately 2,000 miles square, and is very sparsely populated, therefore, although good laws exist for the protection of native game, it is very difficult to see that they are enforced in the thinly populated districts. For example, Queensland has an area of 670,000 square miles, but its population is only about 190,000 whites, and approximately 9,000 aborigines. New South Wales is better, having an area of 309,460 square miles and a population of 1,847,214. Victoria has an area of only 87,884 square miles, but has a population of 1,397,977, so is considerably more dense than the other States. South Australia consists of 380,070 square miles and has 433,616 people, but Western Australia had the large area of 975,920 square miles and a population of only 308,806.

The Northern Territory, also is a large district, consisting of 523,620 square miles, and inhabited by only 4,767 people, excluding natives. The island of Tasmania has 26,215 square miles, with a population of 199,925.

In glancing over these figures one can easily realize the difficulty in fully enforcing game laws. The only way that native animals surely can be preserved for those that come after us is, to form Reserves in various types of country. This is being done in many of the States, but only to a limited degree at present, because the subject is a difficult one. Introduced foxes and domestic cats that have gone wild, to say nothing of rabbits, cannot well be kept out of these Reserves. The foxes and cats prey on the protected game, and the rabbits destroy the native grass and shrubs that it is sought to preserve. Of course, these animals are not all over Australia yet, but they certainly will

be in course of time, despite fences, and we cannot possibly estimate the havoc they will play with the ground game and water fowl. It is quite possible that some species will become extinct before we realize it.

Then again, parts of Australia are subject to severe droughts, and thousands of small animals, as well as birds and kangaroos, perish, and emus cannot migrate as they used to do, on account of fences and settlements. The sheep and cattle help to denude the country and drain the waterholes. Therefore, in some districts where certain forms of life formerly were in evidence, none are seen now. Take as an example about fifty miles inland from Rockhampton in Queensland: there the beautiful parrakeet, (*Psephotus pulcherrimus*) was fairly plentiful, but since the drought in 1896 not a bird has been seen in the whole district. The pig-footed bandicoot was comparatively common in the southern districts of Australia, but now one is rarely, if ever, found.

Gilbert's rat-kangaroo, (*Potorous gilberti*), of southwest Australia, apparently is extinct. The so-called native cat, (*Dasyurus*) was exceedingly plentiful in Victoria, but now they are just as scarce as they once were plentiful. It is difficult to say why these various animals have almost disappeared. Of course the settlements and what they bring with them might account for a good deal, but certainly not for all. We really know little as to the unaccountable disappearance of small mammals in districts where they were numerous, and when we wake up to the fact that they have gone, it is usually too late to take measures of protection. Probably the same thing occurs in America, and elsewhere.

The introduction of foxes into Australia by private persons is bound to cause the destruction, and possibly, extinction of certain ground game. Inasmuch as much of the country has been cleared of scrub, the game does not have the same cover that it had formerly. The animals that live in burrows probably will hold their own longer than those that make their nests on the surface. Tasmania being of comparatively small area, is sure to lose the marsupial wolf or thylacine before long, as the dense bush is cleared and the country becomes more thickly

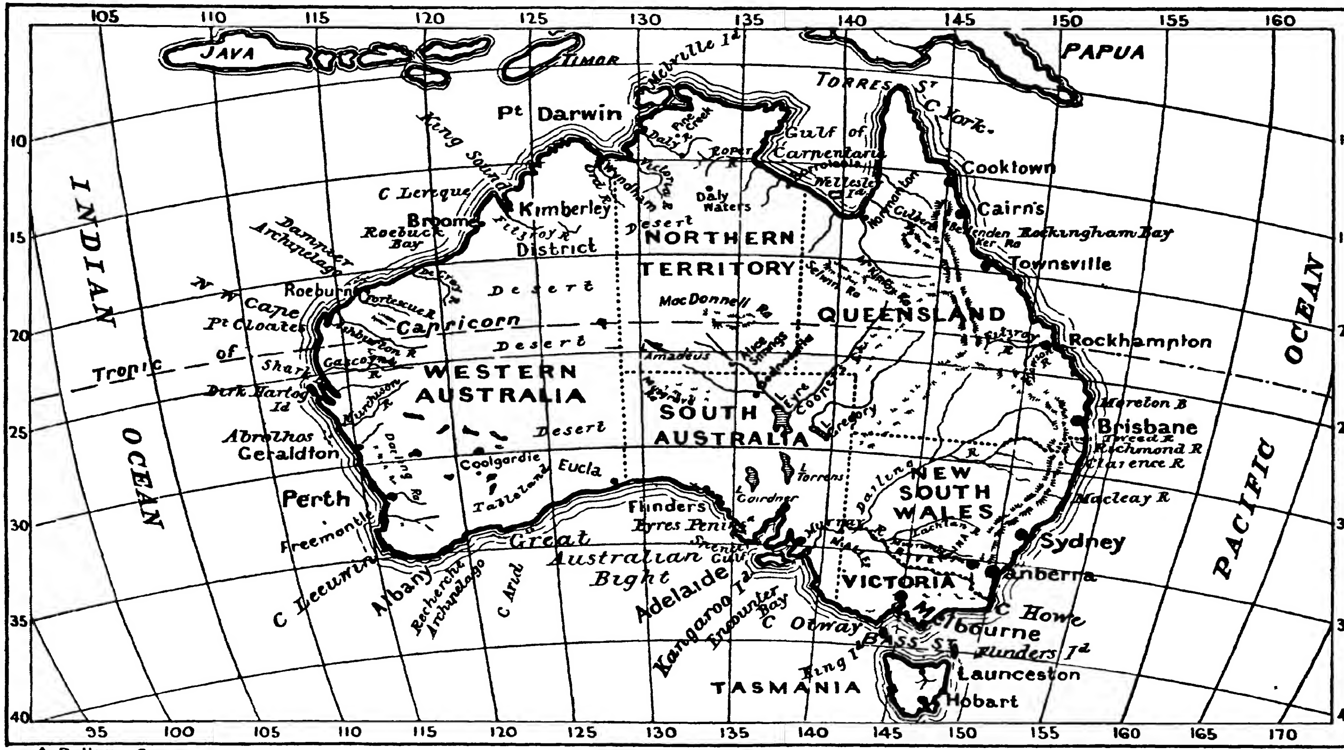


FIG 33 AUSTRALIA GREAT BRITAIN S SOUTEASTERN EMPIRE

The development of Australia outruns the imagination. How many Americans know that a great transcontinental railway now links Brisbane, Sidney and Victoria with far-distant Perth and Western Australia? Notwithstanding her tremendous outpouring of men, munitions, ships and money for the war Australia is vigorously maintaining her chain of zoological gardens, and a remarkable series of sanctuaries for the preservation of wild life.

settled. Even now it is scarce, and the settlers snare and destroy it whenever they get the opportunity. The Government has lately established a large Reserve for it near Hobart.

In Queensland there are ninety-two Honorary Rangers, and that State is trying to protect its animal life, but having so much sparsely populated country it is difficult. In the near future, they probably will convert more Crown Land into Reserves. So far only four have been made for animals and fifty-two for birds. It is now under consideration to take up the subject of the exportation of the skins of Australian native wild animals, and to place this important matter on a proper basis. It probably will be under the control of the Commonwealth Government, and further efforts then will be made to preserve our fast disappearing fauna. In every country there are what are popularly called "game hogs," heedless men as well as thoughtless boys, who seek to destroy the fauna of the country for their own individual benefit, and with no thought for posterity, or whether they are exterminating the fauna or not. Simply for what they call "sport," they carelessly destroy all they can, making little use of what they do kill. Persons of this class always are with us, more or less.

THE MAMMALS OF AUSTRALIA.

DINGO.

The Dingo, (*Canis dingo*) is found over the whole of Australia, but curiously enough not in Tasmania or the adjacent islands to the north. It probably is one of the most ancient of wild dogs, and its anatomy shows it to be an intermediate form between the wild dogs of South America and those of the old world. It is a true wild dog.

These animals are usually met with singly or in pairs and only occasionally in small packs, and then they probably would be parents and young. They never attack a human being. They usually hunt at night, but their scent is so keen that they frequently capture ground birds by stalking them and then catching them as they rise on the wing from the ground. They are the size of a sheep dog, and the ears are short and erect. The

fur on the under part of the body is gray, the longer hairs, which give the body coloring, are reddish-yellow to much darker shades and in some specimens the saddle is almost black. The Western Australian dogs are, as a rule, darker than those in Victoria. The feet and tip of the tail are usually white.

Albinos sometimes occur and as these often breed true, a white race could easily be established. The females always seem to predominate. They are fleet and strong and can overturn a sheep or calf with ease, should the mother of the latter be absent. However tame they may appear in captivity, they cannot resist the temptation of killing a fowl, should they get an opportunity. They bite with a snap like a wolf, and animals bitten by them seldom recover.

In the open country these dogs can be ridden down by a good horse and despatched with a stirrup iron or waddy, or even caught if necessary. They are readily poisoned with strychnine. When the aboriginals of Australia found Dingo pups they used to rear them with care, tame them partially, share their bed and food with them, and the dogs then would only follow their owners. They were never struck by the natives, but these partially tamed dingoes often joined their wild comrades in the bush and did not return. The natives used them for hunting, but they apparently only followed their master. These animals breed freely with European dogs and consequently it is now difficult to obtain a pure bred Dingo. They never bark, but can howl dismally.

The fossil bones of these animals have been found in several parts of Australia in a formation that is considered to be Pliocene, so that apparently they were in existence in Australia long before human beings.

WATER RAT.

The Water Rat, (*Hydromys chrysogaster*). This is a large, handsome rodent fully twenty inches long from nose to tip of the tail. They are dark buff above, a rich orange-brown below, and the tail is white toward the end. These animals are still fairly plentiful, but being nocturnal are seen rarely. They are purely aquatic and frequent inlets of the sea as well as rivers

and lakes, where they feed on the shell-fish, crustaceans and vegetation. They are found in all parts of Australia and Tasmania. The western species is slightly darker than those found in the eastern side of Australia and the amount of white on the tail also varies. A small rat, dark grey on the back, called Thomas' Rat, (*Xeromys myoides*) is found in Queensland. Its body is only four and one-half inches long and its tail three and one-half inches.

RATS.

Due to their remarkable fecundity, rats are very plentiful in Australia, as in other parts of the world, both in species and individuals. Both rats and mice occasionally increase during an unusually good season, when food and cover are plentiful, to almost incredible numbers. During the year of 1917, there was an abundance of rain in southern Australia throughout the summer which produced a great growth of grass and other vegetation. Therefore, as food was plentiful and the vegetation so dense, the rodents were securely hidden from their enemies. They increased so enormously that food became scarce, especially where the grass began to get dry, and they had to migrate in their many millions. They were then preyed on by snakes, carnivorous animals and birds, but despite this, the destruction caused by these little rodents was very great. At the wheat stacks alone at eight railway stations in Victoria, about thirteen tons of mice, representing approximately 892,000 animals, were caught in three days. The same migrations occur in other countries, especially among the lemings in Norway.

MICE.

The members of the genus *Mus* are represented in Australia by twenty-eight species so far known. But this number is certain to be increased later on. As our knowledge of these animals is very incomplete at present, an authentic list cannot well be given. Of our twenty-eight species, only five can be termed mice, although it is difficult to draw a dividing line between the two species. They are met with practically every-

where, increase rapidly, and all burrow more or less. One of the commonest species is the Dusky-Footed Rat, (*Mus fuscipes*), is found in South Australia, the islands of Bass Straits and Tasmania, usually near water or on swampy land. Its body length is about six inches and the tail is about four inches. The fur is conspicuously long.

A closely allied form, (*M. assimilis*) or the Allied Rat having very soft fur, which is light brown above, is found from N. E. Queensland to S. W. Australia, usually in thickly timbered country. They live largely on fruits and seeds. On the Darling Downs in Queensland, the *M. sordidus* is found. It is blackish-brown above and measures about six and one-half inches, with a tail five inches long. Generally in open country, and at the extreme N. E. of Australia, the White-Footed Rat, (*M. terrae-reginae*) is plentiful. Its back is dark brown, with longer black hair and tail with light colored rings. It measures eight and one-quarter inches and the tail seven and one-quarter inches.*

M. gouldi is reddish-yellow in color, with numerous long black hairs above. It measures four and one-half inches and tail three and one-half inches. It is found in south, eastern and central Australia. And *M. greyi* inhabits central and north-eastern Australia and is reddish brown in color with longer dark hairs. It is six inches long and its tail four and three-quarter inches. One small species in Western Australia, *M. nanus*, is only four inches long and its tail three and one-half inches. It is brown in color and has a white patch under the tail. The Pigmy Mouse, (*M. delicatulus*) from Northern Australia is only two and one-half inches and the tail about the same length. It is yellowish-brown in color and the upper parts and the sides of the body are yellow.

The Greyish-White Mouse, (*M. albocinereus*) is found near the seashore in S. W. Australia. Its body is covered with long, soft, light grey hair and the tail and feet are white. The Brown Rat, (*M. decumanus*) and Domestic Mouse, (*M. musculus*) have spread over most of Australia and have become numerous in many districts in the country, as well as in the towns. The

*In a short article like this full descriptions of the various species cannot well be given. (Author.)

former have from two to three litters a year each containing from nine to fourteen young. The European Black Rat is also in evidence, not only in the cities, but chiefly in the country, as they have the habit of building their nests in hollows in trees and are therefore largely arboreal.

JERBOA RATS.

The interesting family of Jerboa Rats of the genus *Conilurus* (*Hapalotis*) is confined to Australia where they are also plentiful in many districts, their long ears and tails making them conspicuous. The fossil specimens that have been found are of great interest as illustrating in the rodents a mode of progression similar to that of the kangaroos. These little animals advance by leaps and bounds like the Jerboas of Africa and Asia and the jumping mice of North America. Fourteen species are known so far, mostly confined to the interior, although some varieties live in the coastal districts of north Queensland.

They have from three to four young, but have no pouch; the young being attached firmly to the nipple and also grasping their parent with their claws. They are strictly nocturnal, resting during the day in nests of dried leaves and grass in hollow fallen branches. The largest varieties, *C. boweri* and *C. hirsutus* are nearly two feet in length and are found in north Queensland.

The White-Footed, (*C. albipes*) is found in the southeastern districts. This animal is greyish-brown, black around the eyes, and has a body length of ten inches and a tail nine and one-half inches. The nest-building Jerboa Rat, (*C. canditor*) from the interior of eastern Australia is only six inches long, and its tail five inches. They combine together and make large nests of grass, sticks and bits of bark sometimes over three and one-half feet high, usually around a small bush, the branches of which help to strengthen the structure. One family or more may occupy a nest and each family has its own compartment, which is connected with the others by passages that put one very much in mind of a beaver's lodge. This animal is greyish-brown and is darker on the center of the back and head.

The Long-Tailed Jerboa, (*C. longicaudatus*) inhabits Western Australia and is seven inches long, with a tail nine inches. It is pale buff on the back and the end of the tail is white. It is usually found in scrub-covered country. The Fawn-Colored Jerboa, (*C. cervinus*) is four and one-half inches long and the tail five and one-half inches long. It is found in the central districts of South Australia. The large ears of this delicate looking little animal are much lighter in color than its back and are very conspicuous. It is all white below. A rat named the Dusky Broad-Toothed (*Mastacomys fuscus*) is found in Tasmania. It is only five and one-half inches long and is dark greyish-brown in color.

GIANT RATS.

The largest rat in Australia, the Giant Rat, (*Uromys macropus*) is found from northeastern Australia to the Arnheim Islands. It is fourteen inches long with a tail about the same length, and rarely is seen in captivity. It is reddish-grey above and white below and is probably destructive to birds' eggs and young during the nesting season. The Buff-Footed Rat, (*U. cervinipes*) found in Western Australia only, is but six inches long with a tail a little over five inches. It is light brown above, with buff-colored feet. The scales on the tails of these animals do not overlap but are set edge to edge.

MUSK RATS.

We now come to the animals that are strictly marsupial, and in Australia they are naturally numerous. The Australian Musk Rat, (*Hypsiprymnodon moschatus*) usually found in the scrub-covered country of the coastal districts of Queensland, is a graceful little animal, with soft and orange-grey colored fur, diurnal in habit and living on insects, snails, fruit and seeds. It has two young at a time in its pouch, and its length is about ten inches and tail six and one-half inches. It is rarely seen and the perfume of musk easily identifies it.

KANGAROOS.

All kangaroos have more or less the same habits and are usually found in small companies in country where they are not disturbed. They are protected for the whole year in Victoria and soon increase if undisturbed. Partial protection is given to them in New South Wales, but not in Queensland, except in certain districts. The number of skins annually sent to other countries from Australia, especially from Queensland, runs into many thousands. Of this number, the United States receives a large share; sometimes over 80,000 in one year.

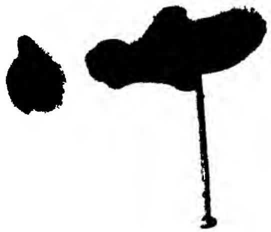
Many men make their living entirely by shooting kangaroos with a rifle; one man I know having shot over 400 last year (1917). This means that in the course of comparatively a few years, these interesting animals will become very scarce, as the skins of all species, including wallaby, are used for leather. The introduction of the fox into Australia will not help matters as they are sure to kill some of the young ones. These animals fortunately live and breed freely in confinement, having but one young at birth, although twins have been known to occur occasionally.

They are hunted on horseback with the aid of a large dog of the grey-hound type, known as a kangaroo dog, and if the country should be sufficiently open, they usually are caught and killed. When hard pressed, they often will take refuge in a river or in swamps standing waist deep in the water and awaiting their enemies. Should a dog swim out to them, they will hold it under water with their fore arms and eventually drown the venturesome animal. When attacked on land, the old males that are not as speedy as the females, often stand with their back to a tree ready to fight with the dogs; and they are usually quite a match for any single dog. Young kangaroos are often caught and reared by hand, when their mother has been shot or otherwise killed. Their backs are easily damaged if roughly handled. When leaning forward to feed on short grass, they often rest on the upper part of their paws, as well as on the under part in the ordinary way. When in this position, the young that may be in the pouch, and old enough, can nibble on the grass at the same time.

The Grey Kangaroo, (*Macropus giganteus*) is found across the entire southern part of Australia as well as in Tasmania. The species from that island (*M. fuliginosus*) is now very scarce. It has long, dark fur and the under parts are white. The female is much lighter in color than the male. Those on the western side of the mainland usually are darker, but generally melanism is more pronounced among the animals in the western portion of Australia than in the eastern. These animals are only a little inferior in size to the red kangaroo, and the fur is longer and coarser. The males are a dark grey and the females and young much lighter. They are found in open forest country and frequently are called locally the Forester Kangaroo. The variety from Tasmania and Kangaroo Island (*M. fuliginosus*) is now very scarce. It has long, dark fur, the under parts being white. The female is paler than the male.

The Wallaroo of Euro Kangaroo, (*M. robustus*) have long and coarse fur; the color of the male being dark reddish-grey and that of the females more bluish-grey. Farther north in Queensland, the color is often dark greyish-brown in the males. The exact tint varies considerably. This variety is found in the central districts of Australia, as well as towards the coast. They live only on the rocky ranges and are thickset and strong and adepts at bounding over the often rough country where they are found, and where frequently it is difficult for a dog to follow them.

Several sub-species of this animal, (*M. woodwardi*) from northwest Australia, have been described. The color of the short, close hair of the male is bright red and that of the female, fawn. The head and body measures four feet and the tail three feet. The fur of *M. alligatoris* from north Australia is also short and the color more or less rufous, with the neck, arms and fore-back, fawn. Another sub-species from southwestern Australia, *M. cervinus*, is lighter in color, and lastly *M. isabellinus* from Barrow Island off west Australia, has a dark rufous back with the front of the neck white. In the southern districts of Australia, in the drier and frequently sandy country where the mallee eucalyptus grows, is found a darker and more slender variety of kangaroo, the Black-Faced, (*M. melanops*). However,



Photograph by W H D LeSouef

FIG 34 YOUNG GRAY KANGAROO, *M giganteus*

Immature specimen just born and placed in the pouch Beside it is the the nipple to which it would have been fastened about life size

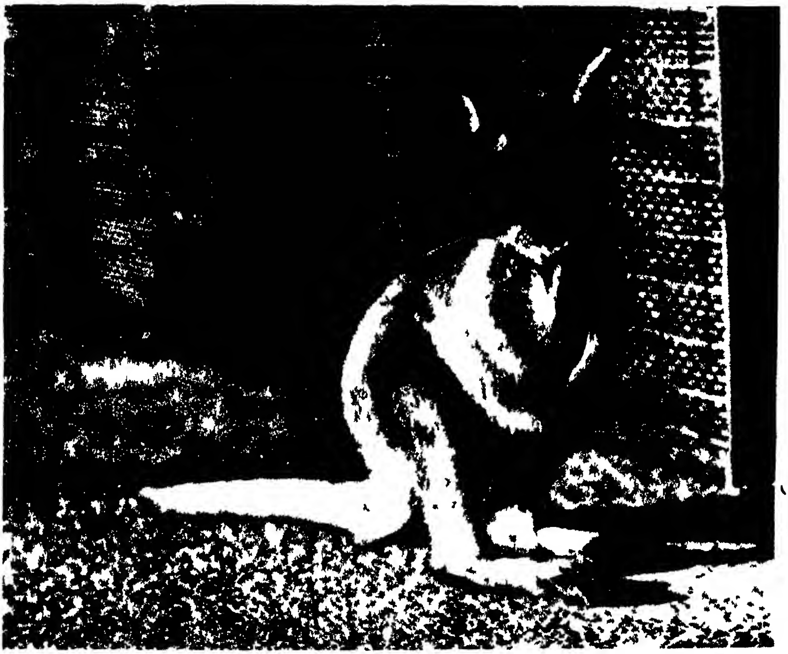


FIG 35 WALLAROO OR EURO KANGAROO

New York Zoological Park

Photograph by F R Sanborn

FIG 36 WOODWARD KANGAROO

New York Zoological Park

Photograph by E. R. Sanborn

FIG. 37. BLACK-FACED KANGAROO
New York Zoological Park

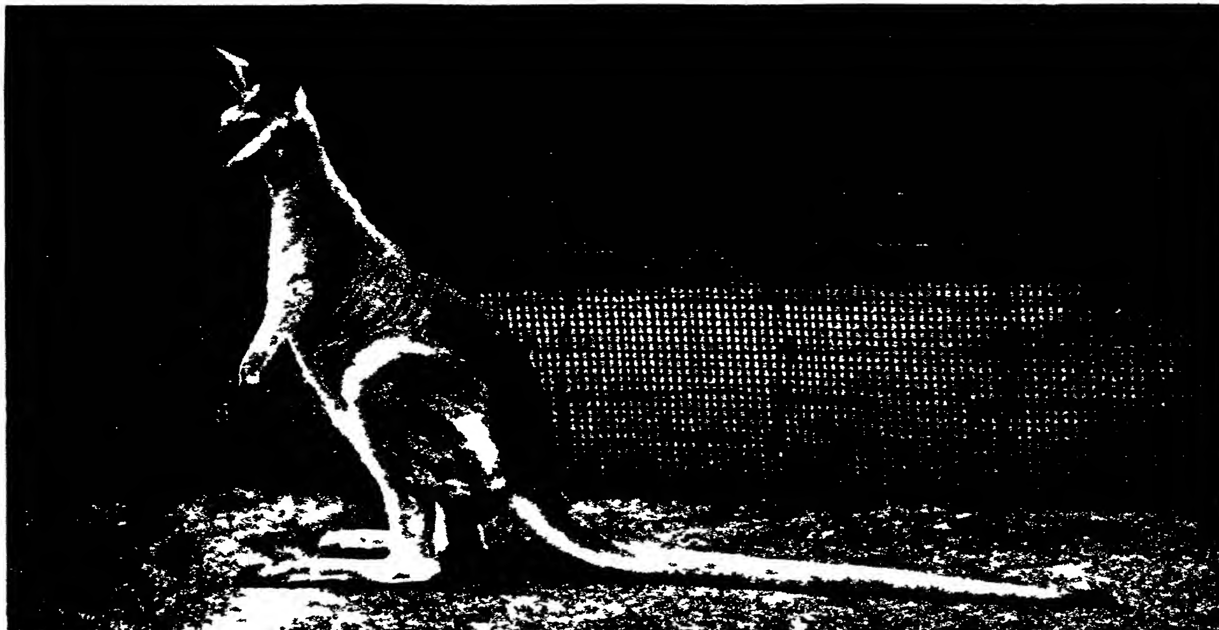
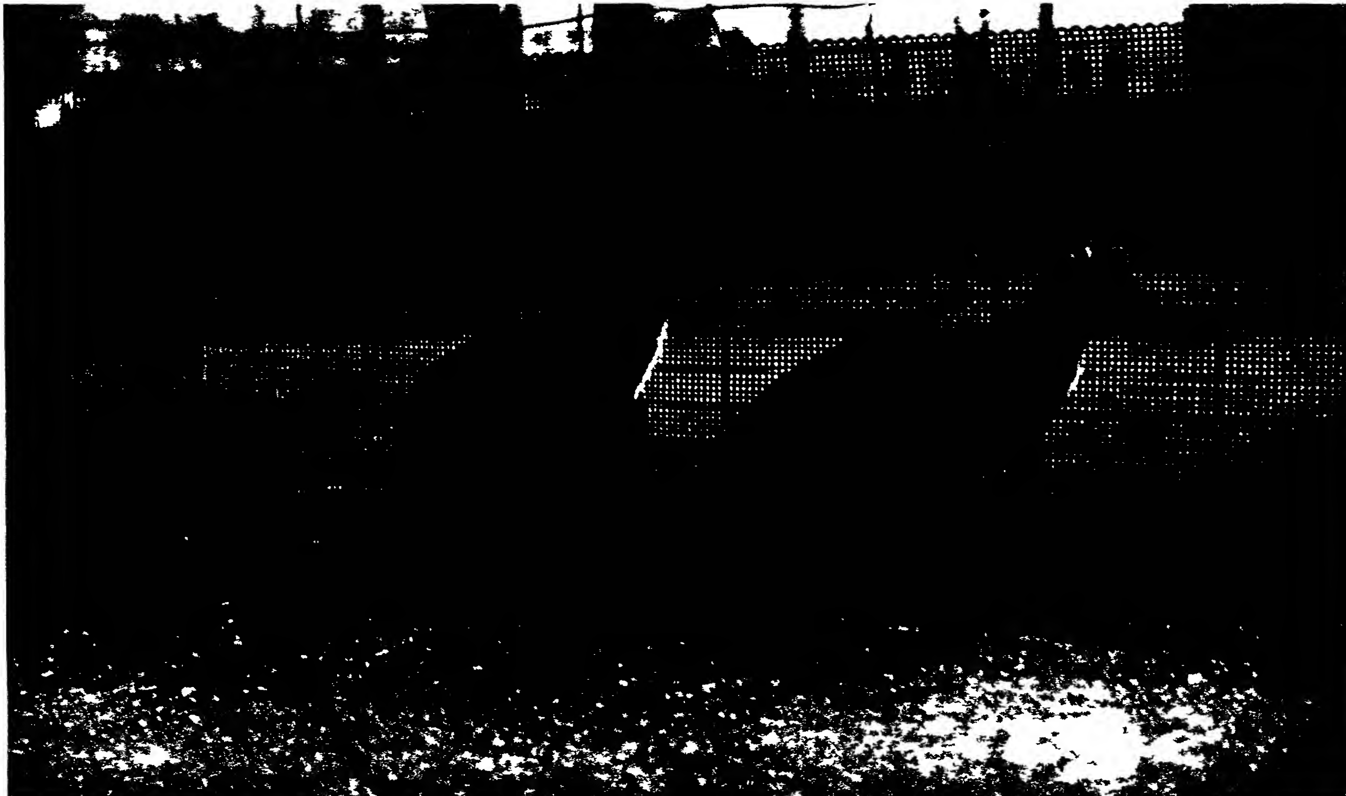


FIG 38 PARRY KANGAROO
New York Zoological Park

FIG. 39 GIANT RED KANGAROO
New York Zoological Park



Photograph by F R Sanborn

FIG 40 KANGAROO ISLAND KANGAROOS

New York Zoological Park

Photograph by E. R. Sanborn

FIG. 41. BENNETT TREE KANGAROO

The tail is not prehensile, but is used in balancing. The forefeet are adept in grasping. These animals sometimes leap to the ground from a height of fifty feet.

New York Zoological Park.

FIG 42 BENNETT TREE KANGAROO
They both climb and nimbly jump from branch to branch

FIG 43 CAPTIVE TREE KANGAROOS
In the Zoological Gardens at Melbourne Australia

FIG. 44. RUFOUS-NECKED WALLABY
New York Zoological Park.

Photograph by W H D Le So

FIG 45 BRUSH-TAILED PHASCOGALE

Young attached to nipple

Photograph by W H D Le Souef

FIG 46 BENNETT TREE KANGAROO *D bennettianus*

Showing pads on the hind feet

Photograph by W H D Le Souef

FIG 47 ALBINO RED KANGAROOS

Melbourne Zoological Gardens

Photograph by W H D LeSouef

FIG. 48. ALBINO RED-BELLIED WALLABY

Tasmania

FIG. 49. RING-TAILED WALLABY
New York Zoological Park.

FIG. 50. BUSH-TAILED WALLABIES
New York Zoological Park.

Photograph by E R Sanborn

FIG 51 BLACK SWAMP WALLABY

Young kangaroos seek refuge in the mother s pouch until one-third grown This young specimen was fully weaned but rushed for the mother upon the slightest disturbance

New York Zoological Park

Photograph by E R Sanborn

FIG 52 MALE OF THE SWAMP-WALLABY
The dexterous manipulation of the forefeet is clearly shown
New York Zoological Park

FIG 53 AGILE WALLABY
New York Zoological Park

as this country is being cleared rapidly for wheat-growing, this animal will become scarce, as it is destroyed by the farmers.

Kangaroos are diligently sought for their skins, and although they are well protected in Victoria, and to a certain extent in other parts of Australia, their numbers are diminishing. A small, slender species, Parry's Kangaroo, (*M. parryii*) is found in the hilly coastal districts of Queensland and northern parts of New South Wales. The short, soft and light bluish-grey fur marked with a white line on each side of its face as well as on the neck, and the long, thin tail, have suggested its local names, the Pretty-Face or Whip-Tail Kangaroo. It usually frequents scrubby country and often may be seen in the Darling Downs district from railway carriages when one is travelling from Brisbane to Sydney, or vice-versa. It is three feet in height and its tail is two and one-half feet in length. The Red Kangaroo, (*Macropus rufus*) is probably the largest of the kangaroos. The short, woolly fur is red in color in the male and bluish grey in the female. When standing upright, practically on its hind toes, and resting the weight of its body on the end portion of the tail, it measures about six and one-half feet; otherwise four to five and a half feet.

Old males get very pugnacious and frequently fight one another. They do so by scratching, if possible, with their fore paws, and also by leaning back and resting the weight of their body on the extreme end of their tail, only about six inches, and striking forward with the hind feet. The claws are sharp and although they do not often do much damage to each other, they can easily rip up an unwary dog should one tackle them. These animals live on the plain country of New South Wales and southern Queensland, generally remaining during the heat of the day under the shade of the trees that fringe the plains. They can easily travel at the rate of twenty miles an hour when pursued, and exceed that speed when pressed. They cover about twelve feet at a jump and can clear a fence eight to ten feet high. Occasionally they are pursued on the plains with motor cars, although I hardly think that is a fair way to get them, as they have no chance, unless they get into a belt of timbered or rough country. However, the sport is not destined to be very popular

as motoring over the plains at over twenty miles an hour is usually a very bumpy experience. A female kangaroo when hard pressed in flight if she should be carrying a heavy young one, or *joey* in her pouch, will take the young one out and conceal it under a bush, coming back when all danger is over, should she have a chance.

The only safe way to hold a kangaroo is by the tail, and it takes a strong man to hold one. The young are born in the ordinary way, but in a very immature state. They are about an inch long, the fore feet are twice the size of the hind feet and the tail very small. It is placed on the nipple in the marsupium by the mother and the pressure of the milk forms a small bulb at the end of the nipple at the back of the mouth. This swelling being larger than the entrance to the mouth of the young one, holds it on. If the young kangaroo is pulled off at an early stage it cannot be replaced.

The Antilopine Kangaroo, (*M. antilopinus*) is found in the Coburg Peninsula in north Australia, and very little is known of this animal. It is of a heavy build with short fur, rufous in color with underparts white. The female is smaller and of a fawn color. The head and body are four and one-half feet and the tail two feet long.

THE TREE WALLABY.

These interesting animals are found in the mountain ranges near the coast of northern Queensland as well as in New Guinea. Two varieties inhabit Australia, namely Lumholtz's, (*Dendrolagus lumholtzi*) and Bennett's, (*D. bennettianus*). The former which has long yellowish-brown fur with a black chin and white chest is found in the more southern districts near Cardwell, and the latter which has long dark brown fur, further north near Cooktown. Like most of the other grazing Australian animals, they rest during the day and feed chiefly at night. They live almost exclusively in trees or on the tops of granite boulders that are covered with vegetation. I once saw one of these animals that I disturbed when in the latter situation, jump to a rock

Photograph by W H D LeSouef

FIG. 54. THE HOME OF THE TREE WALLABY

Queensland

below, a distance of about forty-five feet. It is wonderful the way they are able to jump from bough to bough and rarely make any miscalculation. Their long tail is not prehensile and is used for balancing only, and the soles of their hind feet are serrated and that prevents them from slipping.

The natives obtain them by going to the upper portions of the scrub-covered ranges in the early morning with their dogs, and the latter are frequently able to pick up the scent of a kangaroo that has gone from one tree to another or to track it to the tree in which it is feeding. Some of the natives then climb any tree in proximity to the one that shelters the wallaby. to prevent it escaping into it, while another of their number climbs the tree that harbors the animal, and either catches it by the tail or forces it to jump to the ground in its endeavors to escape. The other natives with the dogs are there on the lookout for it and generally secure it.

The wallabies frequently get from one bough to another by going along towards the end of a branch, and clinging to it with their fore paws, as it bends they are enabled to get a foothold on one at a lower level. They can also jump a considerable distance from one bough to another. As a rule, when they are on the ground they lean well forward and keep their tail clear of the soil. In ascending a tree, they do so by clinging with their fore paws round a creeper and moving both hind feet up at the same time; and they go up very quickly. They cannot ascend an ordinary trunk of a tree, but as the forests in the districts where they are found abound with creepers, practically every tree having one or more, they have no difficulty in climbing. They also can climb an ordinary two or three-inch rope with ease, or even a gas or water pipe; their serrated pads enabling them to get a secure hold. Should one escape on board a vessel, it quickly climbs the ropes and easily gets to the mast-head. These animals in their native state are more or less infected with two or three kinds of parasites and often have sore places caused by them. As their food consists of leaves of various shrubs, they live well in captivity.

WALLABIES.

There is little difference between kangaroos and wallabies. The members of the genus *Macropus* whose head and body are over four feet in length are called kangaroos, and those three feet and under, usually wallabies. One of the largest of the latter is the Black-Tailed, (*Macropus nalabatus*) measuring just under three feet and the tail two feet. This animal, which is of rather a heavy build, and not nearly so active as many of the smaller kinds, is always found in scrubby country. Its color is very dark brown or reddish-grey and light rufous underneath. They formerly existed in countless numbers in the densely timbered portions of the coastal districts of New South Wales and Victoria, and hundreds of thousands of their skins have been exported. But trappers and settlements have so reduced their numbers that they are now protected in Victoria. During the day they usually remain well hidden, coming out in the evening to feed. A very closely allied variety, (*M. apicalis*) is found in the same class of country in the coastal districts of Queensland. It has shorter fur and the rufous color is more intense. Probably the largest of these animals is the Red-Necked Wallaby. It is of more slender build than the preceding species, is greyish-fawn in color, with a reddish neck and rump, and measures three and one-half feet and its tail two and one-half feet. It is found in the eastern parts of Australia from southern Queensland to Victoria where it usually inhabits the open forest country.

The Tasmanian form of this wallaby, (*M. bennettii*) has thicker and longer fur and is slightly darker in shade. Its neck and rump are dull brown instead of red. It also is found in southern Victoria and on the islands in Bass Strait. Formerly it was very plentiful, especially in the Islands, but now the hunters with their dogs have completely exterminated them also, except in Tasmania, where they still hold their own in the rough parts. In captivity they easily become tame and do not knock themselves about in the way other species often do. In Victoria and South Australia, Grey's Wallaby, (*M. greyi*) is found. It is a slender animal and can travel very fast. The color is greyish-fawn with a rufous tinge on the neck. It measures about two and one-half feet in length and its tail slightly under. An-

other fine wallaby, the Black Striped, (*M. dorsalis*) is found in the inland districts of New South Wales and southern Queensland. The general color is grey with a reddish tinge on the forequarters, and it is readily distinguished by a narrow black line down the center of its back. It measures slightly over two and one-half feet and its tail two feet.

The Black Gloved Wallaby, (*M. irma*) from southwestern Australia is a well-marked animal, with soft fur of a bluish-grey above, white below the chin, cheeks stripes also of the same color, and another white stripe on the neck, edged with darker color. They measure about three feet and tail two and one-half feet, thrive well in captivity and make very docile pets. The Agile Wallaby, (*M. agilis*) is a heavier animal with short, coarse dark sandy-colored fur, very short ears and a long tail that easily distinguishes it. The habitat of this species is southeast New Guinea, as well as in the northeastern portion of Australia. The Cape York Wallaby, (*M. coxeni*), another species from northeast Australia, is also a dark sandy color, darker on the back with white underparts and a white hip-stripe. These animals are small, being only twenty-eight inches long and their tail fourteen inches.

The Branded Wallaby, (*M. stigmaticus*) is found also in northeast Queensland, but usually further south than the beforementioned species. It is of slender build, the fur is short, of a bright reddish-grey color, with less red on the neck and forequarters. There is also a pale cheek-stripe, the hip-stripe is yellowish and prominent, and the underparts white. It measures twenty-nine inches in length and its tail fourteen inches. The Red-Legged Wallaby, (*M. wilcoxi*) is very similar to the preceding one, but the color is duller, and the hip-stripe hardly visible. It is found in the southern districts of Queensland and the northern parts of New South Wales.

The Pademelon Wallaby, (*M. thetidis*), found in eastern Australia from southern Queensland to Victoria, is a light, graceful little animal, grey in color, reddish on the neck and white below. Its ears are long, and the hip-stripe is very faint. It measures twenty-six inches and its tail sixteen inches. The Dama Wallaby, (*M. eugenii*) from West Australia, the islands

off that coast and South Australia, has thick, dark grey fur with reddish shoulders and a pale cheek-stripe. This little animal is about the same size as the preceding one.

The Parma Wallaby, (*M. parma*), very closely allied to the former species, has an even reddish-grey color with a distinct cheek-stripe and a white front. It is found in eastern New South Wales. The Rufous-Bellied Wallaby, (*M. billardieri*) used to be exceedingly numerous in Victoria and especially on the islands in Bass Straits, as well as in Tasmania, but those on the islands have been nearly cleared out. The hunters with packs of kangaroo dogs, used to burn the thick patches of scrub in which they knew the wallabies had taken refuge during the day and their dogs caught the unfortunate animals as they ran out. Their habitat is in the dense scrub and although their runs are very numerous in such places, they are fairly safe under ordinary circumstances. Many hundreds of thousands of their skins have been exported. These animals are of stout build, have thick, soft fur of a dark greyish-brown color, face and head olive-grey and no face markings. The body measures twenty-seven inches and the tail which is very short, only fourteen inches.

The Short-Tailed Wallaby, (*M. brachyurus*) from Western Australia is the smallest of the wallabies. Its body measures twenty-three inches and its tail ten inches. Its fur is long and coarse and is a uniform greyish-brown. The ears are small and rounded. Its habits are identical with those of the rufous-bellied wallaby.

The Rock Wallabies, (*Petrogale*) are found all over Australia, but not in Tasmania. As their name implies they live only in rough rocky country, whereas the members of the family *Macropus* are usually found in the more level districts. The Rock Wallabies lean well forward, using their long, bushy tails only for balancing and not as a third support, as do the Macropus family, especially the larger forms. The underside of the toes are covered thickly with small tubercles that prevent the animals from slipping on the rocks, especially when they are wet. They usually take refuge during the day in caves or under rocks, coming out to feed in the evening and at night. The

wonderful way that they can bound freely and without hesitation from rock to rock, sometimes onto excrescences that can hardly be seen, is extraordinary. A dog naturally and fortunately has little chance of catching them. In the many runs among the rocks that have been used by countless numbers of these animals for many years past, the rocks are perfectly polished and shiny. No ordinary fence will stop this active animal, and, should they escape from captivity they seem to enjoy hopping about the roofs of buildings, apparently quite at home and where they cannot well be followed.

The largest of the group is the Yellow-Footed, (*P. xanthopus*). The body measures thirty-two inches and the tail twenty-four inches. The fur is long, soft and grey in color. It has a prominent white cheek-stripe, an orange spot above each eye, and long ears. A black line extends from the head to the middle of the back, there is a brown patch behind the elbow and a white lateral line that runs to the hip. On top of the knee there is another brown patch, and alongside of it a patch of white, and the arms, bands, legs and feet are yellow. The tail is marked above with alternate bands of dark brown and pale yellow. This handsome animal lives in South Australia.

Another variety, the Brush-Tailed, (*P. penicillata*) found in the eastern coastal districts of Australia, is a thick set animal with long, coarse brown fur, a light cheek-stripe and short ears. It measures thirty inches long and the tail, usually tipped with yellow, is twenty-four inches.

The Western Australian form, (*P. lateralis*) is smaller in size. The body being two feet long and its tail one and one-half feet. The fur which is light grey, is long and soft and its cheek-stripe yellowish. It also has a dark line on the center of the upper part of the back, a dark brown patch just behind the elbow, and a prominent white stripe running down to the hip. The latter half of its tail is black.

Another form from the northwest coastal districts of Australia is the Short-Eared, (*P. brachyotis*). This little animal is also slender, with short greyish-brown fur, has practically no face markings, the body markings only just visible and is grey-

ish-white below. The body measures twenty-two inches and the tail sixteen inches.

There are three wallabies belonging to the genus *Onychogale* (Nail-Tailed). They are well marked animals having fairly long tails, crested at the ends and provided with spurs. These are the only marsupials that have such an excrescence. Among mammals, the lion is the only one that has a similar spur. The Nailed-Tailed Wallaby, (*O. unguifera*) from northwest and north-central Australia is a slender and graceful fawn-colored animal, with a darker medium band, and white hip-stripes and under parts. The body measures twenty-six and the tail twenty-eight inches. The tail is long and white on the upper side with a few, faint brown rings showing towards the end, which is black. The spur is flattened laterally and hidden in the long hairs.

Another variety, the Bridled, (*O. frenata*) is found in the eastern districts of Australia from South Queensland to Victoria. These slender little animals having a body length of but twenty-three inches and tail of eighteen inches, make charming pets and when hopping along have the habit of holding their fore paws straight out in front of them. Their grey fur is soft and thick. The cheek-stripe is indistinct, the center of the back of the neck is black, and there is a white shoulder-stripe and a very indistinct hip-stripe.

The West and South Australian form, Cresent, (*O. lunata*) is very similar to the preceding species. The fur is a soft dark grey, and the neck is rufous. The white shoulder-stripe is prominent and there is a faint stripe above the hip. It measures twenty-one inches and the tail fifteen inches.

The Hare-Wallabies, (*Lagorchestes*) of which three varieties are known, form another interesting group of these animals. The name was given because of the likeness in form, size and habits to the hare. They are found usually in plains country, can travel at great speed and are adepts at dodging any dog that may be chasing them. The Spectacled Wallaby, (*L. conspicillatus*) is found on the islands off the west coast of Australia. On the mainland, the closely allied variety of this species has been named *L. leichhardti*. Their color is yellowish-grey with

a reddish band round the eye and two light lateral bands. They measure about twenty-one inches and tail eighteen inches. The colors of the mainland form are brighter and the bands and under parts are white.

The common Hare-Wallaby (*L. leporoides*) is found in the interior districts of New South Wales and South Australia. It is light in structure and its general color is like that of the common hare, with the exception of a black patch on the elbow and also the reddish band round the eye. It measures about twenty inches and the tail about thirteen inches. The last variety is the Rufous, (*L. hirsutus*). It is found in the more southern districts of West Australia and is greyish in color, with a reddish tinge behind, and no black patch on the elbow. It measures eighteen inches and the tail fifteen inches.

In the same part of Australia, the graceful Banded Wallaby, (*Lagostophus fasciatus*) is found. It usually lives in thick, scrubby country and is still plentiful in places. It is greyish-brown in color and has three sets of fur. First, grey under-fur, then grey, coarser hair and then long well separated piles projecting well beyond the others. It has no marks on its face or flanks. The lower part of the back has dark and light transverse bands that identify this little animal readily.

KANGAROO RATS.

We now come to the Rat-Kangaroos, or as they are called in Australia, Kangaroo Rats. They formerly were exceedingly plentiful, but dogs and foxes have taken a heavy toll of them and in the settled districts they have almost disappeared. They are about eighteen inches in length with a tail fourteen inches, and are of a sandy-grey color. They usually sleep coiled up in their nests during the day, coming out to feed in the evening and at night. The largest of them, readily distinguished by its reddish-grey color, the Rufous, (*Aepyplymnus rufescens*) is found only in New South Wales, and is twenty-one inches long with a tail fifteen inches. It has an indistinct stripe in front of the hips.

There is another family of these active little animals, namely the Bettongs, (*Bettongia*), characterized by the fact that they

are the only ground animals having prehensile tails, which they use for carrying bundles of grass for the construction of their nests. A hollow is first scraped out in the ground and in it a dome-shaped nest of grass is built; the top being about level with the surface of the ground. The animal upon entering the nest draws a bunch of grass after him, and closes the entrance so perfectly that the nest cannot be observed, easily. A fox or dog, however, can readily detect the presence of the owner; if he happens to be at home. If he should be, there is little hope, for the intruder simply pounces down on the nest and usually secures the owner. The varieties of these animals are closely allied externally and are difficult to identify without knowing the locality from which they came. The Tasmanian variety, (*B. cuniculus*) is slightly the largest and has white feet instead of brownish, as in the others. The underparts are white and, generally, there is a white tip on its tail. The New South Wales variety, (*B. gaimardi*) has hair of a more woolly texture than the others and white hind paws; also a few white hairs at the tip of the tail. The Brush-Tailed Rat-Kangaroo, (*B. penicillata*) is found all over southern and central Australia and has a body length of fourteen inches. The tail which is twelve inches long has a black crest along the upper surface of the lower portion, but not white hairs at the tip. The phinarium is bare of fur as in the other species. This is the variety that is usually seen in captivity.

The West and South Australian variety, (*B. lesueuri*), also found on some of the islands off the coast of West Australia, has a tail twelve inches long. Some specimens have a light stripe across the hip, and a white tip on the tail. The Plains Rat-Kangaroo of which there is but one species, (*Caloprymnus campestris*) found in the plains country of South Australia, is a slender animal with a broad face, and sandy-colored, thick, soft fur, which is darker on the back. The feet are white, and the middle of the chest usually has a bare patch. It is very quick in its movements when chased, and dodges about so cleverly that it is difficult to catch.

Probably, the rat-kangaroo that has the widest range is the Common, (*Potorous tridactylus*). It is found all over south-

eastern Australia and Tasmania. There are only three varieties of this family. The hind feet are short, and the tail short and tapering. When travelling fast, they use their fore feet as well as their hind ones. They never kick with their hind feet as the other rat-kangaroos do. The head of the Common is narrow and long, and is larger than the other two varieties. It measures seventeen inches and its tail nine and one-half inches, but the size varies; those found in Tasmania probably being the largest. The fur is long, coarse and greyish-brown in color, and the ears short and rounded, and the tail usually is tipped with white.

Gilbert's Rat-Kangaroo, (*P. gilberti*) is found in the southern districts of West Australia and is smaller than the aforementioned; otherwise externally identical. The other form, (*P. platyops*) is also from southwestern Australia and is still smaller, measuring only eleven and one-quarter inches, and tail seven and one-half inches. It is called the Broad-Faced; which characteristic is very noticeable. It is otherwise externally the same as the others. An interesting little animal *Hypsiprymnodon moschatus* has been described from the tropical scrubs in northern Queensland. In size and form like a large rat, it is reddish-grey in color, and the large ears are bare as are also the fingers. It is seen but rarely in captivity, as the animal is hard to detect and capture. It hops like a bandicoot and lives on insect life, as well as fruit and vegetation. It has two young.

PHALANGER OR AUSTRALIAN OPOSSUM.

The Australian Phalangers, locally mis-called opossums, are not carnivorous like the American opossum, but feed entirely on vegetation; eucalyptus leaves forming the principal part. They live entirely in trees, and are nocturnal in their habits, sleeping during the day in some hollow or in their domed nest. They once existed in very large numbers, despite having formed the principal article of food of the aboriginals in days gone by, but as their fur is of value for rugs they have been shot and trapped unmercifully and practically cleared out of many districts; over a million skins sometimes being exported annually from Australia. Foxes are now taking their toll of them in southeast Australia;

catching them as they pass on the ground from one tree to another. They climb the trees by jumping quickly upwards with all feet at once; the sharp claws being extended to their fullest extent and thus securing a firm hold in the bark. They choose the upper side of a tree, should it be reclining in any way, and a defined track will be made on the bark of the one that is much used, which serves to guide the natives in finding the hollow in which the opossums are coiled up asleep. They usually are caught by placing a long, thick branch of stick against the tree, and the animal will always ascend by this in preference to going up the straight trunk. In descending the branch, the animal advances head first, thrusts its head through a wire noose that has been placed on the stick, and thereby meets its fate. Many are shot; a moonlight night being chosen for the purpose, as the animals then can be distinguished against the face of the moon. The skins from the animals that have been shot are not as valuable as those that have been snared.

The smaller race of phalangers, called the Ring-Tailed, (*Pseudochirus*) is found in Tasmania, Australia and New Guinea. They also construct bulky, domed nests of sticks and leaves near the top of some thickly growing shrub, on which their tracks are not easily seen. They have from two to three young at birth which, on leaving their mother's pouch, hang to her back for some weeks, by clinging with their claws to her fur, and are carried about until they are able to look after themselves. As their tail is prehensile and frequently used for clinging, the underpart of the end of it is rough and bare. Sometimes when shot and badly wounded they will hang on by their tails before life leaves them, and remain in that position after death for a considerable time; frequently a day. The end of the tail is usually white. In the Herbert River district in Queensland, a small lemur-like variety, (*P. lemuroides*) is found. The soft, woolly brownish-grey fur is darker on the shoulders and lighter on the hips, and the head is brown and the tail black. It measures fifteen inches and tail twelve inches.

Another closely allied form, *P. herbertensis,* is found in the same district. It is dark brown in color, without markings, and is about the same size, but has a longer tail. Some specimens

have white rings round their limbs. The common Ring-Tailed Phalanger, (*P. peregrinus*) has a wide range, being found from eastern Queensland to the southern parts of South Australia. They still are very plentiful in places, even near the large cities, where they find refuge in private gardens, and frequently are seen in captivity where they soon become very tame. I often have seen them walking along the thin telephone wires in the grounds of the Melbourne Zoo. They use their tails as a balance, moving them quickly from side to side as necessary, and if knocked over they will continue their progress by hanging on by their claws. These animals do not live on eucalyptus leaves like the large kind, but eat almost any vegetation and fruit and are fond of rose vines and other leaves in flower gardens. Their fur is short and its color varies; being varying shades of dark rufous-grey with a patch of white on the edge of the ear. They measure about fourteen inches and their tail about twelve inches.

The form in Western Australia is closely allied but has no rufous shade and the underparts are whiter, and usually there is more white on the end of the tail. There is also little difference in the Tasmanian form, (*P. cooki*). Its thick fur is more woolly in texture and dark rufous-brown in color with more white on the ears. The Yellow Ring-Tailed is found in the coastal districts of central Queensland. Its color of yellowish-green and white below renders it, therefore, easily distinguished. Four forms are found in New Guinea, namely, *P. albertisi* and *P. schlegeli* from the Anfak Mountains, *P. canescens* from Pamoi, and *P. forbesi* from Sogere. The large Phalanger, or as it is universally called in Australia, the opossum, belongs to the genus *Trichosurus*. The species feed chiefly on the leaves of the eucalyptus, resting during the day in hollows in these trees. It is the skins of this phalanger that have been exported in such quantities and are so largely used for fur rugs, etc. The variety that is by far the most plentiful, *T. vulpecula*, is found over the whole of Australia, except on the extreme northeast. Although formerly so abundant, in many districts they have been almost completely exterminated; but when afforded protection, which they now have in many places, and especially in Victoria, they soon increase. They are easily tamed and would be kept as pets more often if they did not sleep coiled up all day long and become

lively only at night. Their thick, woolly fur is grey in color, the under parts whitish, the end of the bushy tail is black and bare on the under side, and there always is a reddish patch on the chest. In making rugs, the bare part of the tail is usually cut off and the backs only used. The ears are long and the body measures eighteen inches and the tail eleven inches.

The Tasmanian variety, *T. fuliginosus,* is larger and has longer fur. Many specimens are dark grey, tinged with rufous, but others are a dark rufous-brown with a black tail. The skins of this latter handsome variety are of considerable value, and the animal has to be rigorously protected to prevent its extermination. In the heavily timbered uplands of Victoria and New South Wales is fonud the Short-Eared Phalanger, (*T. caninus*). Its beautiful fur is very thick and of a dark grey color, although in some specimens it is dark reddish-brown. The short, rounded ears, about one-half the length of the other varieties, render it easily distinguished. This animal is closely allied to the Tasmanian form.

A black form of *caninus,* (*T. c. nigrans*) is found in the coastal scrubland of New South Wales and Queensland. The interesting point is, that the underparts are just as dark as the upper surface. During the summer, however, there frequently is a rufous shade.

KOALA OR NATIVE BEAR.

The Koala, or Native Bear as it is always called, of which there is but one species, (*Phascolarctus cinereus*) is found in all the eastern districts of Australia. They are strictly arboreal, living in the eucalyptus trees, and sitting during the day in a coiled-up position in a fork, where they are more secure. On account of this habit they are therefore easily shot, or killed by the heavy bush-fires. Like phalangers, the young cling to the back of the parent when they become too large for the pouch. The querelous, high-pitched note of the little ones is exactly like the crying of a child, but the old animals utter a prolonged, deep bass note. These animals are grey with white feet, and have thick, woolly fur. They do not possess a tail. An interesting little animal, *Tarsipes rostratus,* that is not often seen in cap-

tivity is found in Western Australia. It is only thirty-one inches in length, and its tail three and one-half inches. The color is grey, striped dorsally with dark brown. Its principal food is insects and it also sucks honey from the flowers.

FLYING-PHALANGER.

Australia possesses several forms of Flying-Phalangers, or as they are popularly called, Flying-Squirrels. When the Phalangers stretch the feet well out, the loose skin that acts as a parachute holds the air sufficiently to allow the animal to glide from the higher branches of one tree to the lower trunk of another; the long, furry tail acting as a rudder. As they alight, a quick upward movement is made, the sharp claws enabling them to hold on to the bark, when they quickly can ascend the tree again and repeat the performance. All the species have beautiful long, soft fur.

The Pigmy Flying-Phalanger, (*Acrobates pygmaeus*), well distributed over the eastern parts of Australia, is a delicate looking little creature, three inches long and with a tail three and one-half inches. The soft, silky fur is greyish-brown, the undersurface is white and the edge of the parachute is tipped with the same color. They usually have four young. On the timbered ranges of the coastal districts of Victoria and New South Wales, a large form of flying-phalanger is found, called the Yellow-Bellied, (*Petaurus australis*). Their color is greyish-brown, but varies in shade. The claws are strong and much curved, to enable them to get a good hold of the tree trunk when alighting. The body length of the species measures eleven and one-half inches and the very long and bushy tail is sixteen and one-half inches. The Squirrel Flying-Phalanger, (*P. sciureus*), a much smaller form measuring only ten inches and tail ten and one-half inches, is light grey with a dark line on the crown. They are easily tamed and make interesting pets. They are found in eastern Australia.

A still smaller form, found in the same districts, namely the Lesser, (*P. breviceps*) is only seven inches in length and its tail slightly longer. It also is light grey and can be distinguished from *P. sciureus* only by its smaller size. The Papuan form,

(*P. papuanus*) is also closely allied, even in markings, but has shorter fur and usually yellowish underneath and is smaller in its measurements. It is found in the Papuan sub-region of New Guinea, as well as on the adjacent islands.

The Striped Phalanger, (*M. dactylopsila trivirgata*), a striking animal with a white body marked by dark, longitudinal stripes and a long bushy tail with a black line on its upper surface, is found from northern Queensland to New Guinea and on the Aru Islands. In the eastern districts of Australia, from southern Queensland to Victoria, is found the Taguan Flying-Phalanger, (*Petauroides volans*). It measures seventeen and one-half inches and the tail slightly longer. The ears are also very large. The fur, generally white below, is dark ashy grey, but it varies much in shade, some being lighter and others again nearly black. The Queensland form is usually smaller and has been named *P. minor*. Probably one form gradually runs into the other.

A small, mouse-like animal, the Dormouse-Phalanger, (*Domicia*) is closely allied to the flying-phalangers, but has no flying-membrane. Two forms are found in Tasmania. One, *D. lepida* measuring only three inches with a tail of the same length, is a graceful little animal, light fawn in color with fine, soft fur like all the others, numerous long whiskers and large ears. The other form, *D. nana,* fawn in color, but with the legs usually grey, also found in Victoria and New South Wales, is slightly larger, measuring four inches and its tail slightly longer. They have four young at a time. These little animals often have fatty accumulations on the body. The Long-Tailed, (*D. caudata*), which is the larger of the genus, comes from northwest New Guinea. It measures four inches in length, tail five and three-quarter inches and the general color is rufous, with two dark lines on each side of the face.

The smallest form, the Lesser, (*D. concinna*), found in South and West Australia, only measures three and one-half inches, with the tail slightly longer. Their color is fawn, and the underparts white. These little animals live well in captivity. Another genus, *Gymnobelideus leadbeateri* has been described from the mountainous districts of southeast Australia (Gipps-

FIG. 55. SHORT-TAILED WALLABY
New York Zoological Park.

Photograph by E. R. Sanborn

FIG. 56. RAT-KANGAROO
New York Zoological Park.

Photograph by F R Sanborn

FIG 57 AUSTRALIAN GRAY PHALANGER

New York Zoological Park

FIG. 58. KOALA OR NATIVE BEAR
Phascolarctus cinereus

Photograph by W H D LeSouef

FIG 59. KOALA IN ITS TREE-TOP HAUNT
An old native bear photographed wild in the bush in Victoria.

Photograph by E R Sanbor.

FIG 60 FAT-TAILED OPOSSUM MOUSE

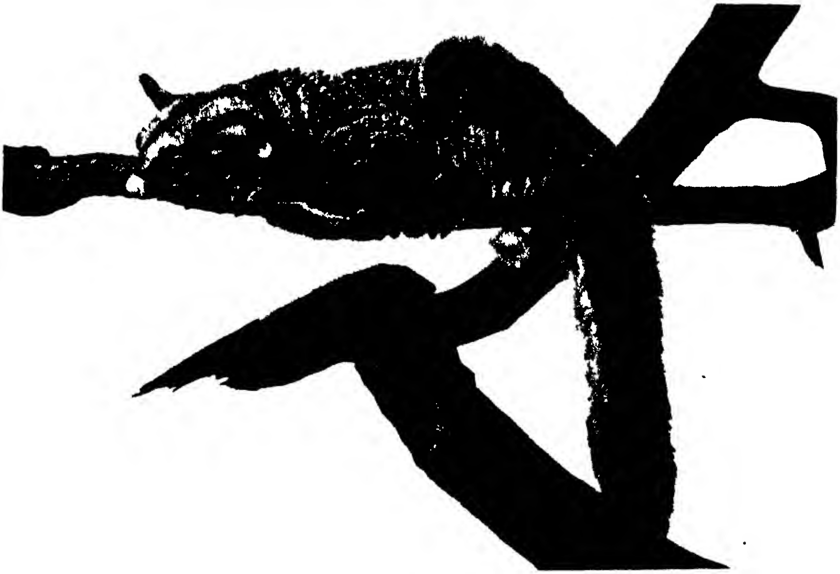


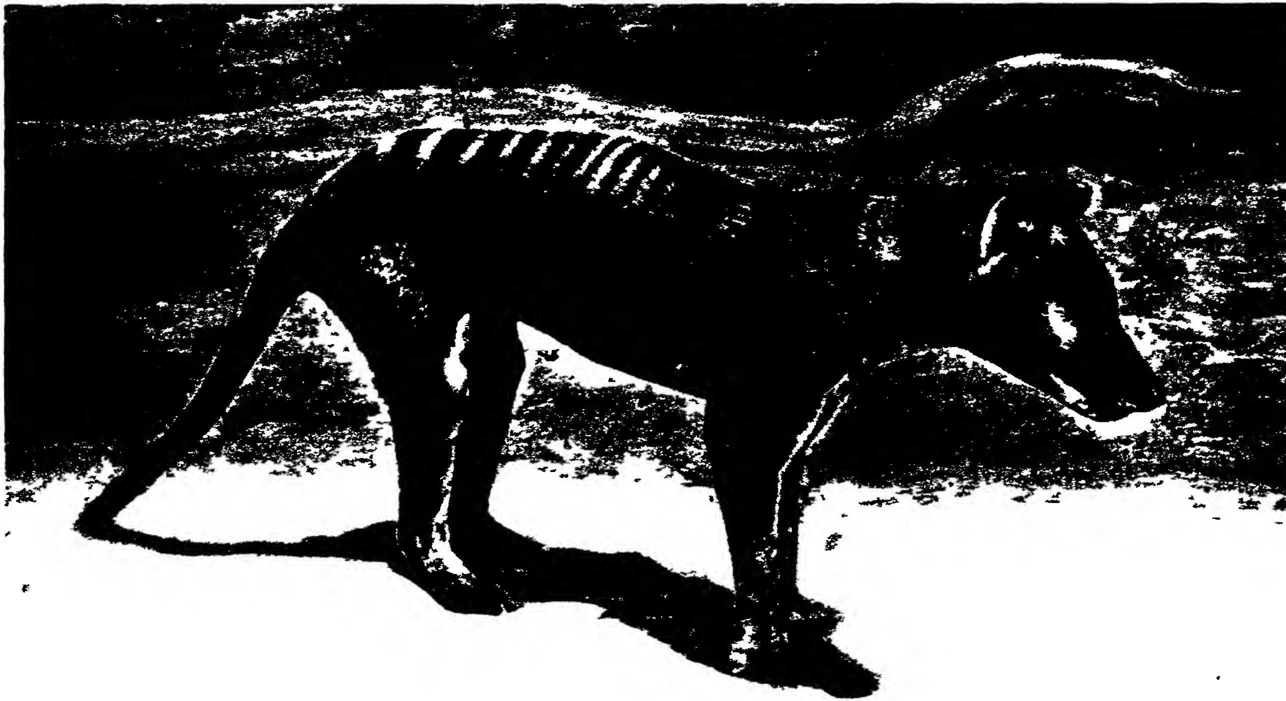
FIG. 61. FLYING-PHALANGER
New York Zoological Park.

Photograph by E R Sanborn

FIG. 62. RABBIT-EARED BANDICOOT
New York Zoological Park.

Photograph by F R Sanborn

FIG 63 WOMBAT AND YOUNG
New York Zoological Park



Photograph by E R Sanborn

FIG 64 TASMANIAN WOLF MARSUPIAL WOLF
New York Zoological Park

land), and is very rarely found. It is five and three-quarter inches long, tail a little longer, and the color of the body is grey with a dark line on the top of its head.

CUSCUS.

The Cuscus (Phalanger family), widely distributed over the islands in the Southern Pacific, are large and arboreal. They subsist on leaves and other vegetation. The Spotted Cuscus, (*P. maculatus*), the only one that is found in Australia, and that, only in the extreme north near Cape York, is also found in the Moluccas, Wai, Amboina, Ceram, Aru, and New Guinea as well as on some of the smaller islands. They live fairly well in captivity.

The fur of these animals is thick and woolly and the general color mottled white, black and red in various combinations. The females are generally dark grey and black without any white, but the markings vary, some color predominating more than others in different individuals. The Grey Cuscus, (*P. orientalis*) is found in Bourn, Amboina, Ceram, Waigin, Aru Islands and New Guinea. The males of these species are sometimes quite white, but the color of individuals varies much in shade. The Short-Eared variety, (*P. breviceps*), slightly smaller and darker than the Grey Cuscus, comes from Duke of York, Solomons, San Christoval and other small adjacent islands, and the Ornate Cuscus, (*P. ornatus*), which is smaller and lighter than the Grey Cuscus, is found in Morty, Ternate and Batchian Islands. In the Celebes and adjacent islands of Sanghir is found another form of Grey Cuscus, (*P. celebensis*).

THE BANDICOOTS.

The Rabbit Bandicoot, (*Peragale lagotis*), from southwest Australia, is about the size of a rabbit. The fawn-grey fur is long and silky, head and ears are long, an indistinct dark line runs vertically from the back on the sides of the rump, the underparts are white and the tail towards the end is also white and crested. Bandicoots are destroyed chiefly by dogs and cats, and were far more plentiful in the days gone by than they now are. They are nocturnal; resting during the day in burrows, and feeding at night upon insects, grubs, earthworms, fungus and

roots. They are marsupial and the pouch opens backwards. Their general color is olive-grey, with bars across the lower part of the back. The smaller Bandicoots belong to another species, namely *Perameles.* The Short-Nosed, (*P. obesula*) is the most widely distributed, being found all over southern Australia and Tasmania. It is fourteen inches long and the short, coarse fur is grizzled-yellow and black, the underparts are white and the ears short and broad. They are usually found in swampy localities where the vegetation is very dense. The North Australia Bandicoot, (*P. macrura*) is closely allied to the former, but it is larger and darker in color and its tail is longer. The Long-Nosed Bandicoot (*P. nasuta*), found in the central districts of eastern Australia, also is larger than the Short-Nosed, has very coarse hair and is brown in color without any markings. The ears are long and pointed, the underparts are white, and it measures fifteen and one-half inches and its tail five inches. Gunn's Bandicoot, (*P. gunni*) is about the same size as the last mentioned, but has soft fur, yellowish-brown in color and with bands across the rump.

The form in West Australia is the Striped Bandicoot, (*P. bongainvillei*) is of small size being only nine inches long and has coarse olive-brown fur. Another form, (*P. fasciata*) in southeast Australia is closely allied to the former, but the stripes are very conspicuous and the tails are white. The Pig-Footed Bandicoot, (*Cheropus castanotis*), now becoming rare in places, is a small species measuring ten inches, and tail four inches. The name indicates its identity.

THE WOMBATS.

Wombats, (*Phascolomys*) are still fairly plentiful in south-eastern Australia and Tasmania. They dig deep burrows and are safe there from foxes and dogs, as they are quite able to defend themselves. Their length averages about forty-four inches. They prefer scrubby, mountainous country and their food is entirely vegetable. They are nocturnal, resting during the day in their burrows. They have no tail.

The common variety, (*P. mitchelli*) is found in Victoria and New South Wales. They vary in color from dark yellowish-grey

to black. The Tasmanian, (*P. tasmaniensis*) is smaller and usually of a dark greyish-brown color, and the Flinders Island form, (*P. ursinus*), the form originally but incorrectly described as from Tasmania, is yet smaller, being thirty-six inches in length. The Hairy-Nosed (*P. latifrons*), grey in color with the end of its muzzle white, is found only in South Australia. They are not as uniformly colored as the other varieties. These animals are very strong and burrow with great rapidity with their powerful claws; a habit that makes them very troublesome to settlers, as they dig under and damage wire-netting fencing. In walking, they shuffle along in a clumsy manner. They live well in captivity, but are very subject to skin disorders.

TASMANIAN WOLF.

The Marsupial Wolf, (*Thylacinus cynocephalus*). These rare animals probably will become extinct before very long, as the settlers are prejudiced against them on account of their destruction of sheep and other stock. The dark marks across the back are so very striking and distinctive, that the animal is usually called locally the Tasmanian Tiger. They utter a peculiar coughing bark, rapidly repeated and something like that of the kangaroo. They have a fair sized pouch which opens backwards and usually bear from one to two young at a time.

These animals resemble in form some of the short-legged wolves, but have short, close hair. During the day they generally sleep in hollow logs, holes, under rocks, and pursue their prey in the evening and at night. They are not very fleet of foot but have a keen scent and usually spring on their prey, which consists, besides the stock of settlers, of wallabies, rat-kangaroo's and other ground game. They swim well and readily cross rivers in pursuit of their prey, one having been recently observed swimming a river after a wallaby; quickly overtaking it. They are now found only in Tasmania, but their bones have been found in Australia. Why they disappeared from the mainland, it is difficult to say.

TASMANIAN DEVIL.

The Tasmanian Devil, (*Sarcophilus ursinus*) is strictly terrestrial and is now found only in Tasmania, although formerly it was plentiful in the southern districts of Victoria, judging by the remains found. But these animals were apparently extinct before the arrival of Europeans. They are strong but sluggish beasts and, having powerful canine teeth, are a match for any ordinary dog. They are carnivorous and can bite severely, while the molar teeth enable them to crush bones with ease. As the Tasmanian Devil is comparatively slow of movement, it usually catches its prey by a sudden spring, afterward devouring it greedily bones and all. It utters a disagreeable kind of snort. The three to four young, when too large to remain in their mother's pouch, generally cling to her back. They lie up in hollow logs or burrows during the day, coming out at night to catch their prey. They are destructive to poultry and lambs, consequently have few friends and are being killed out of all settled districts. Their color is jet black with a white horse-shoe mark on the chest, but they often have patches of white on other parts of the body. So far I have not seen an albino specimen such as one finds among the kangaroos and wallabies.

SPOTTED DASYURE.

The Spotted Dasyure or, as it is popularly called in Australia, the Native Cat, formerly used to exist in thousands in South Australia, but from some unknown cause these pretty little animals have now disappeared from many districts. There are three varieties, namely, the North Australian, (*Dasyurus hallucatus*), which is small, only measuring eleven inches and its tail eight inches; the Black-Tailed, (*D. geoffroyi*) from all Australia except the extreme north and the coastal districts of the southeast, and the Common, (*D. viverrinus*) from eastern New South Wales, Victoria, South Australia and Tasmania. These animals are marsupial, having about six young ones at birth. They are usually of a reddish-grey color, but also often black and are well marked with white spots, but not on the tail which is usually white at the tip. They measure about seventeen inches and their tail ten inches. A larger variety, the Spotted-Tail, (*D.*

Photograph by E T Luke

FIG 65 A FAMILY OF TASMANIAN DEVILS
Melbourne Zoological Gardens

Apparently this rather forbidding animal has received its name partly from its color and partly from its savage temper and strength of jaw It breeds in captivity and frequently is seen in collections of living animals

maculatus) found from eastern Queensland to Tasmania, is more than twice the size of the other species. These animals can climb well although they are mostly terrestrial, taking refuge during the day in hollow logs and among rocks, etc. If several are kept in the same compartment in captivity, they are liable to turn cannibals; the stronger eating the weaker. They are carnivorous, taking birds and their eggs, mice, rats, bandicoots, and other game, and are very destructive to poultry. Consequently, they are not spared by the settlers. They are plentiful in Tasmania; more so than on the mainland.

MARSUPIAL MICE.

A form of Pouched Mouse with habits the same as the others, is the genus *Phascogale*. Their pouch is hardly visible. They bear from six to ten young ones at birth, living principally in holes in trees and lining their nests with grass and leaves. Nine species have been described, namely: the Crest-Tailed, (*P. cristicardata*), which measures about five and one-half inches with a tail three and one-half inches much thicker at the base, is found in central and southern Australia; *P. macdonnellensi* from central Australia has an abnormally thickened tail at the base. The Lesser Brush-Tailed Pouch Mouse, (*P. calura*), also found in southern and central Australia, is five inches long and has a tail six inches. *P. penicillata* or Greater Brush-Tailed Mouse is ten inches long and tail nine inches, is the largest of this genus. They are found all over Australia except at the extreme north, and live almost entirely in trees, making their nests in the hollows of the branches. They have thick tails and the end is covered with long, black hair, forming a brush. There is a very small variety named *P. minutissima,* found in southern Queensland and New South Wales, that is only three inches long. The Yellow-Footed, (*P. flavipes*) with yellow legs and feet, as its name indicates, ranges from eastern Australia to New Guinea. In Tasmania and the adjacent islands, a small variety is found, *P. minima,* or Little Pouched Mouse, with a body length of five inches, and tail three and one-half inches, and in Queensland a still smaller form is *P. minutissima* or Pigmy Pouched Mouse, only three inches long and tail two and one-half inches. Tasmania and southern

Victoria has still another variety, *P. swainsoni* which has long soft fur. In West Australia is found the Freckled, (*P. apicalis*), which is freckled, reddish-grey above. Australia is well off for Marsupial Mice, and other varieties certainly will be found, as these little animals are easily overlooked. Insects form a large part of their food.

Marsupial or Pouched Mice, (*Sminthopis*) are slender and active little animals, from three to four inches long, with large ears and a well developed pouch in which they carry the three to four young they have at birth. They are terrestrial, insectivorous and do not often burrow. Their grey fur is soft and fine. Six species have been described, *S. larapinta,* from Central Australia near the Finke River and the Fat-Tailed, (*S. crassicaudata*), which is found all over Australia except the north. Both of these little animals have the basal portion of their tail much thickened. The Common, (*S. murina*) is found over the southern and central portions of the continent. *S. psammophila* lives near Lake Amadeus in Central Australia, among the sand hills covered with tussocks of porcupine grass. The White-Footed, (*S. leucopus*) extends over eastern Australia from Cape York to Tasmania and is plentiful in certain localities. *S. virginiae* is known only in eastern Queensland. It is five inches long.

An interesting animal found in southwestern and southern Australia, of which but one species is known, is the Marsupial Anteater, (*Myrmecobius fasciatus*). It frequents both the ground and hollows in the trees and its food consists of insects, generally. The fur is short and strong, of a general rufous color which darkens to black toward the tail, with prominent bands of white. It therefore is distinguished readily. The underparts are light yellowish. The females have no pouch, the young adhering to the nipples. It leaps along the ground like a squirrel with the tail slightly raised. They make charming pets and never attempt to bite. It measures ten inches long and its bushy tail seven inches.

THE ECHIDNA.

Of these most interesting animals, the Echidnas, or as they usually are called in Australia the Porcupine Anteater, there are

Photograph by E. R. Sanborn

FIG. 66. UNDER SURFACE OF THE ECHIDNA
New York Zoological Park

Photograph by E. R. Sanborn

FIG. 67. ECHIDNA IN NORMAL ATTITUDE
New York Zoological Park

three varieties, namely, that found in New Guinea, (*Echidna lawesii*), about fourteen inches in length, which has short spines; the Brown Echidna, (*E. setosa*) from Tasmania, with long hair almost concealing the spines, and the Australian form, (*E. aculeata*) which is slightly larger than the New Guinea variety, being about seventeen inches long and without as much hair as the Tasmanian species. These animals live entirely on the ground and their food consists of small insects, and, especially termites and ants, which they easily can obtain by digging with their powerful claws into the ant's nests or termites mounds. The tongue which is covered with sticky saliva is then protruded and when covered with ants is drawn back into the mouth. In captivity they are fed on finely chopped raw meat, eggs and milk. They have no true teeth, but have small spines at the back of the tongue. Their tail is rudimentary and the feet short and strong. When in danger, the animal rolls itself up something like a hedgehog. The sharp spines not only are presented to its enemy, but also are stuck into the ground, making it harder to lift up. The only way it can be carried conveniently is by grasping it by its hind feet, so that its head hangs down. It can dig in any hard soil by the aid of the spines as well as by the strong claws, and it is remarkable how quickly it seems to sink into the ground. It also can hold so tightly to the soil that it is only with difficulty that it can be raised, even by the aid of a spade or strong stick. It also is very difficult to dislodge from the corner of a room, and can climb over almost any wire fence and also out of any ordinary box at the corners, and unless the lid is very firmly nailed on, will push it off, and get through a very small aperture. The strength of the animal is astonishing and even if tightly fastened by a cord around one of its hind legs, is almost certain to get it off. These animals generally hibernate during the winter; usually under the surface of the ground, and frequently by a rock or rising ground. It is at this time that the egg is laid and the young hatched. The shell of the egg is soft and not calcified, and measures about half an inch. The mother by rolling herself up helps to protect the young which are in her pouch, and as the female has no nipples the young one when hatched has to lick the milk from the folds in the pouch. The young Echidna leaves the pouch just as the

spines begin to appear and when it is a little over three inches long. The pouch then gradually disappears until the next breeding season. Like the kangaroo, it is very rarely that two young are born. These animals are more or less nocturnal, as are nearly all the Australian animals.

PLATYPUS.

The Duck-Billed Platypus, (*Ornithorhynchus anatinus*) is of great interest. Like the Echidna it belongs to the genus *Monotremata,* but passes its time in water and not on land, except when coiled up in its burrow with its tail tucked underneath, which usually is most of the day. It seeks its food generally in the evening or sometimes during the day in some very sheltered spot, feeding on earthworms, shell-fish, crustaceans and water insects, generally; a certain amount of which it can store in its cheek pouches. Although the young have rudimentary teeth, they have none when they reach an adult stage; horny plates developing in the place of them which enables the animals to masticate their food, which they usually do when lying on the surface of the water. The fur, which looks very much like that of a seal when the longer hairs are removed, is of two kinds; the longer being shiny and crisp and the under fur soft and short. The bill is soft and leathery, but shrinks considerably when dry, as in museum specimens. The underparts are lighter in color, usually greyish white. The tail is broad and flat and of a dark color above. The underpart is usually devoid of hair, especially in the older animals. Their eyes are very small, but as their bill is usually sensitive, they generally can find their insect prey by a sense of touch.

Being unable to raise the body high from the ground like ordinary animals they can only shuffle along in an awkward manner. It is a burrowing animal and makes a long upward tunnel in the river banks, sometimes thirty feet in length, usually starting at the roots of a tree that grows to the water, with the entrance generally under the surface of the water. At the end is a small chamber lined with leaves and grass, generally not so far from the surface of the ground, so that the natives frequently can tell where the nest is by striking the surface of

FIG 68 THE PLATYPUS OR DUCK BILL

We regret to say that owing to the food habits of this most remarkable animal it is never seen alive outside of Australia There is little ground for hope that a living platypus can be brought to New York and shown in captivity

the ground above and listening for the echo. When swimming, the claws and web are stretched out to their full extent, but on land the extended web is always doubled up underneath; the end of the claws then coming in contact with the ground. In nearly all specimens in museums, the web is expanded beyond the claws, although the animal is represented as being in the ground. But that is incorrect. These animals are very timid, and though they possess no external ears, they are very quick at hearing, and any suspicious sound makes them dive out of sight. The male measures about eighteen inches, tail six inches. The spur on its heel is larger than that on the female. The latter animal is about fourteen inches in length. The shell of the egg is of a tough, leathery texture, and from two to four eggs are laid at a time. As the mother has no pouch, she practically makes one by rolling herself up in her nesting chamber. She has no nipples, but the mammery glands which are in two groups, are underlying the skin on the underside, and the milk is pressed out by a contraction of the muscles and the young takes its food by applying its flat face and tongue to the lacteal surface. These animals are found in the rivers of Tasmania and eastern Australia, except the extreme north.

MOLE.

Australia possesses a marsupial mole, (*Notoryctes typhlops*) found in central and western Australia, but, naturally it never is seen in captivity. As a matter of fact they will not live in captivity. It is about six inches long, with a curious ringed tail about an inch in length, and much thickened at the base. The nose has a hard shield. The fur is soft with an irredescent effect, and varies in color from a yellowish tint to chestnut-brown. They have two young at birth, live underground entirely, are without eyes and subsist on insect food.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBERS 7, 8 AND 9

THE HIGHER VERTEBRATES OF BRITISH GUIANA

WITH SPECIAL REFERENCE TO THE FAUNA OF BARTICA DISTRICT

No. 7. LIST OF AMPHIBIA, REPTILIA AND MAMMALIA

No. 8. BIRDS OF BARTICA DISTRICT

No. 9. LIZARDS OF THE GENUS *AMEIVA*

BY WILLIAM BEEBE

Honorary Curator of Birds and Director of the Tropical Research Station

PUBLISHED BY THE SOCIETY

THE ZOOLOGICAL PARK, NEW YORK

MAY, 1919

Volume II, Number 7

HIGHER VERTEBRATES OF BRITISH GUIANA

WITH SPECIAL REFERENCE TO THE FAUNA OF BARTICA DISTRICT

By William Beebe
Director, Tropical Research Station

In the course of recent studies of neotropical vertebrates, with reference to future ecological work in the field at the Tropical Research Station of the New York Zoological Society, I have been in constant need of lists of the Vertebrata of British Guiana.[1]

Finding no résumé available of the Amphibia, Reptilia and Mammalia of this colony, I have gone through the literature at hand and made my own lists. These I offer as a preliminary enumeration of the species thus far recorded in literature, or in my own collections, from this British Colony. They form a tangible basis for future increments—the many new species and the radical extension of present known distributions which intensive study of these phyla in British Guiana is certain to achieve. Check-lists of mere names such as these are wholly foreign to the future zoological work of the Tropical Station, but they are absolutely necessary as a basis for identification and investigation, and it is in this spirit that this preliminary work has been undertaken.

I have made no attempt at a thorough search of literature for priority or for confirmation of names or other similar phases of taxonomy, deeming this the special province of the literary systematist. I have merely sought to utilize the most recently accepted names of herpetologists and mammalogists. In general I have followed the classification of Gadow in the Cambridge Natural History, Volume

[1]A preliminary survey of the fishes has been made by Prof. C. H. Eigenmann in his "Freshwater Fishes of British Guiana," and lists of the birds are available in Brabourne and Chubb's "The Birds of South America," in Chubb's unfinished "Birds of British Guiana," and in my "Tropical Wild Life," published by the Zoological Society in 1917.

VIII, for Amphibia and Reptilia, and that of Osborn in "The Age of Mammals" for Mammalia. Dr. J. A. Allen has kindly criticized the mammalian names, and to John Tee-Van, a member of my Tropical Station staff, I am indebted for untiring search through many scores of volumes for British Guiana records.

The lists of names are unannotated, and in each case I have given one authentic record for British Guiana, not necessarily the first in published priority. An asterisk before a name indicates that the species has been collected within a radius of ten miles of the Zoological Society's Research Station in Bartica District. This locality is indicated on the adjoining map.

The total number of species is as follows:

		British Guiana	Bartica District
I.	Class **AMPHIBIA** (Coecilians, Frogs and Toads)	52	35
II.	Class **REPTILIA**	112	54
	CHELONIA (Turtles and Tortoises)	11	5
	CROCODILIA (Crocodiles)	4	1
	LACERTILIA (Lizards)	34	21
	OPHIDIA (Snakes)	63	27
III.	Class **MAMMALIA**	119	48
	MARSUPIALIA (Opossums)	10	5
	CHIROPTERA (Bats)	36	3
	CARNIVORA (Jackals, Raccoons, Otters and Cats)	16	12
	RODENTIA (Agoutis, Porcupines, Rats and Mice)	27	8
	EDENTATA (Sloths, Anteaters and Armadillos)	8	8
	PRIMATES (Monkeys)	9	5
	ARTIODACTYLA (Peccaries and Deer)	8	4
	PERISSODACTYLA (Tapirs)	1	1
	SIRENIA (Sea-cows)	1	1
	ODONTOCETI (Dolphins and Whales)	3	1

CLASS: AMPHIBIA

Order APODA; **Limbless, Burrowing Coecilians**

Family Coecilidae

Coecilia gracilis Shaw
Boul. Cat. Batr. Brit. Mus. 1882.

Siphonops annulatus (Mikan.)
Beebe Coll. Bartica Dist. 1916.

Order ANURA; **Frogs and Toads**

Family Pipidae

***Pipa americana** Laur.
Boul. Cat. Batr. Brit. Mus. 1882, p. 459

Family Bufonidae

Bufo guttatus Schneid.
Boul. Cat. Batr. Brit. Mus. 1882, p. 291

***Bufo molitor** Tschudi
Beebe Coll. Bartica Dist. 1916

***Bufo marinus** (Linné)
Boul. Cat. Batr. Brit. Mus. 1882, p. 316

***Bufo typhonius** (Linné)
Beebe Coll. Bartica Dist. 1916

***Bufo sternosignatus** Keferst.
Beebe Coll. Bartica Dist. 1916

Family Hylidae

***Hyla maxima** (Laur.)
Boul. Cat. Batr. Brit. Mus. 1882, p. 349

***Hyla crepitans** Wied
Boul. Cat. Batr. Brit. Mus. 1882, p. 352

***Hyla indris** (Cope)
Boul. Cat. Batr. Brit. Mus. 1882, p. 353

***Hyla pardalis** Spix
Beebe Coll. Bartica Dist. 1916

Hyla albomarginata Spix
Boul. Trans. Linn. Soc. London, (2) VIII, 1900, p. 56

***Hyla punctata** (Schneid.)
Beebe Coll. Bartica Dist. 1916

Hyla granosa Boul.
Boul. Cat. Batr. Brit. Mus. 1882, p. 358

Hyla fasciata (Cope)
Schomb. Reise Brit. Guiana, III, 1848, p. 660

***Hyla boans** Daud.
Beebe Coll. Bartica Dist. 1909

Hyla leprieurii Dum. & Bibr.
Boul. Cat. Batr. Brit. Mus. 1882, p. 362

Hyla taurina (Steindachn.)
Boul. Cat. Batr. Brit. Mus. 1882, p. 363

Hyla venulosa (Laur.)
Boul. Cat. Batr. Brit. Mus. 1882, p. 365

Hyla aurantiaca Daud.
Boul. Cat. Batr. Brit. Mus. 1882, p. 388

Hyla acuminata Cope
Boul. Cat. Batr. Brit. Mus. 1882, p. 403

***Hyla rubra** Daud.
Boul. Cat. Batr. Brit. Mus. 1882, p. 404

***Hyla lineomaculata** Werner
Beebe Coll. Bartica Dist. 1909

Hyla evansi Boul.
Proc. Zool. Soc. London, 1904, II, p. 106

Phyllomedusa bicolor (Boddaert)
Boul. Cat. Batr. Brit. Mus. 1882, p. 427

Phyllomedusa hypochondrialis Daud.
Boul. Cat. Batr. Brit. Mus. 1882, p. 430

Family Cystignathidae

***Pseudis paradoxa** (Linné)
Boul. Cat. Batr. Brit. Mus. 1882, p. 186

***Ceratophrys cornuta** (Linné)
Beebe Coll. Bartica Dist. 1909

Eleutherodactylus marmoratus (Boul.)
Boul. Trans. Linn. Soc. London, (2) VII, 1900, p. 56

***Leptodactylus lineatus** (Schneid.)
Boul. Cat. Batr. Brit. Mus. 1882, p. 207

Leptodactylus hylaedactylus (Cope)
Boul. Cat. Batr. Brit. Mus. 1882, p. 240

***Leptodactylus longirostris** Boul.
Beebe Coll. Bartica Dist. 1916

***Leptodactylus pentadactylus** (Laur.)
Boul. Cat. Batr. Brit. Mus. 1882, p. 242

***Leptodactylus poecilochilus** (Cope)
Boul. Cat. Batr. Brit. Mus. 1882, p. 244

***Leptodactylus typhonius** (Daud.)
Beebe Coll. Bartica Dist. 1916

***Leptodactylus ocellatus** (Linné)
Beebe Coll. Bartica Dist. 1909

***Leptodactylus caliginosus** Girard
Beebe Coll. Bartica Dist. 1916

***Leptodactylus gaudichaudii** (Dum. & Bibr.)
Beebe Coll. Bartica Dist. 1916

Family Engystomatidae

Oreophrynella Quelchii Boul.
Boul. Ann. Mag. Nat. Hist. (6) XV, 1895, p. 522.

Oreophrynella Macconnelli Boul.
Boul. Trans. Linn. Soc. London, (2) VIII, 1900, p. 55

***Otophryne Robusta** Boul.
Boul. Trans. Linn. Soc. London, (2) VIII, 1900, p. 56

***Atelopus Proboscideus** Boul.
Beebe Coll. Bartica Dist. 1916

***Atelopus varius** (Stannius)
Beebe Coll. Bartica Dist. 1916

***Atelopus flavescens** (Dum. & Bibr.)
Boul. Cat. Batr. Brit. Mus. 1882, p. 154

***Atelopus pulcher** Boul.
Beebe Coll. Bartica Dist. 1916

***Engystoma microps** Dum. & Bibr.
Boul. Cat. Batr. Brit. Mus. 1882, p. 163

Family Ranidae

***Prostherapis inguinalis** Cope
Boul. Cat. Batr. Brit. Mus. 1882, p. 139

***Prostherapis trinitatus** (Garman)
Beebe Coll. Bartica Dist. 1916

***Dendrobates tinctorius** (Schneid.)
Beebe Coll. Bartica Dist. 1916

***Dendrobates trivittatus** (Spix)
Boul. Cat. Batr. Brit. Mus. 1882, p. 144

***Rana palmipes** Spix
Beebe Coll. Bartica Dist. 1916

CLASS: REPTILIA

Order CHELONIA; **Turtles and Tortoises**

Suborder CRYPTODIRA

Family Cinosternidae

***Cinosternum scorpioides** (Linné)
Beebe Coll. Bartica Dist. 1916

Family Testudinidae

***Nicoria punctularia** (Daud.)
Boul. Cat. Chel. Brit. Mus. 1889, p. 124

***Testudo tabulata** Walb.
Beebe Coll. Bartica Dist. 1916

Family Chelonidae

Chelonia mydas (Linné)
Leechman; Handbook Brit. Guiana, 1913, p. 134

Suborder PLEURODIRA

Family Pelomedusidae

Podocnemis unifilis Trosch.
Schomb. Reise Brit. Guiana, III, 1848, p. 647

***Podocnemis expansa** (Schwigg.)
Beebe Coll. Bartica Dist. 1916

Podocnemis tracaxa (Spix)
Schomb. Reise Brit. Guiana, III, 1848, p. 646

Family Chelydidae

***Chelys fimbriata** (Schneid.)
Schomb. Reise Brit. Guiana, III, 1848

Hydraspis tuberosa (Peters)
Boul. Cat. Chel. Brit. Mus. 1889, p. 223

Hydraspis gibba (Schweigg.)
Boul. Cat. Chel. Brit. Mus. 1889, p. 224

Platemys platycephala (Schneid.)
Boul. Cat. Chel. Brit. Mus. 1889, p. 228

Order CROCODILIA; **Crocodiles**

Family Crocodilidae

Caiman niger Spix
Schomb. Reise Brit. Guiana, III, 1848, p. 647

***Caiman sclerops** (Schneid.)
Schomb. Reise Brit. Guiana, III, 1848, p. 648

Caiman trigonatus (Schneid.)
Boul. Cat. Croc. Brit. Mus. 1889, p. 296

Caiman palpebrosus (Cuv.)
Schomb. Reise Brit. Guiana III, 1848, p. 648

Order LACERTILIA; **Lizards**

Family Geckonidae

Gonatodes annularis Boul
Boul. P. Z. S. 1887, p. 153

***Thecadactylus rapicaudus** (Houtt.)
Boul. Cat. Liz. Brit. Mus. I, 1885, p. 112

***Hemidactylus mabouia** (de Jonnès)
Beebe Coll. Bartica Dist. 1916

Family Iguanidae

Anolis alligator Dum. & Bibr.
Boul. Cat. Liz. Brit. Mus. III, 1887, p. 500

***Anolis sagrae** Dum. & Bibr.
Beebe Coll. Bartica Dist. 1916

***Anolis fusco-auratus** D'Orb.
Beebe Coll. Bartica Dist. 1916

***Anolis ortonii** Cope
Beebe Coll. Bartica Dist. 1916

Anolis punctatus Daud.
Boul. P. Z. S. 1887, p. 153

***Anolis chrysolepis** Dum. & Bibr.
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 90.

Norops auratus (Daud.)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 96

***Polychrus marmoratus** (Linné)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 99

Ophryoessa superciliosa (Linné)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 112

Tropidurus torquatus (Wied)
Schomb. Reise Brit. Guiana III, p. 650

***Plica umbra** (Linné)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 180

***Plica plica** (Linné)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 181

Urocentron azureum (Linné)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 183

***Iguana iguana** (Linné)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 190

Family Teiidae

Tupinambis teguixin (Linné)
Schomb. Reise Brit. Guiana III, p. 65

***Tupinambis nigropunctatus** Spix
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 337

***Centropyx intermedius** (Schleg.)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 341

***Centropyx calcaratus** (Spix)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 342

***Ameiva surinamensis** (Laur.)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 353

***Ameiva punctata** Gray
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 360

***Cnemidophorus murinus** (Laur.)
Beebe Coll. Bartica Dist. 1916

***Cnemidophorus lemniscatus lemniscatus** (Daud.)
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 364

Crocidilurus lacertinus (Daud.)
Schomb. Reise Brit. Guiana III, p. 650

***Prionodactylus oshaughnessyi** Boul.
Beebe Coll. Bartica Dist. 1916

***Cophias flavescens** (Bonnat.)
Boul. P. Z. S. 1887, p. 153

Iphisa elegans Gray
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 425

Calliscinopus agilis Ruthven
Ruth. Occ. Papers Univ. Mich. No. 22, 1916, p. 3

Family Amphisbaenidae

***Amphisbena fuliginosa** Linné
Boul. Cat. Liz. Brit. Mus. II, 1885, p. 438

Family Scincidae

Mabuia punctata (Gray)
Boul. Cat. Liz. Brit. Mus. III, 1885, p. 161

***Mabuia aurata** (Schneid.)
Boul. Cat. Liz. Brit. Mus. III, 1885, p. 190

Mabuia agilis (Raddi)
Boul. Cat. Liz. Brit. Mus. III, 1885, p. 191

Order OPHIDIA ; **Snakes**

Family Typhlopidae

***Typhlops reticulatus** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 28

Typhlops lumbricalis (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 31

Family Boidae

***Epicrates cenchris** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 95

Corallus cookii Gray
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 100

***Corallus hortulanus** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 102

***Corallus caninus** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 103

***Eunectes murinus** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 115

***Boa constrictor** (Linné)
Beebe Coll. Bartica Dist. 1916

Family Ilysiidae

***Ilysia scytale** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 134

Family Colubridae

***Helicops angulatus** (Linné)
Boul. Cat. Snakes Brit. Mus. I, 1893, p. 279

Drymobius boddaertii (Sentzen)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 13

***Phrynonax sulphureus** (Wagl.)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 19

Phrynonax fasciatus (Peters)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 22

Spilotes pullatus (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 23

***Coluber corais** Boie
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 32

***Herpetodryas sexcarinatus** (Wagl.)
Beebe Coll. Bartica Dist. 1916

***Herpetodryas carinatus** (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 74

***Herpetodryas fuscus** (Linné)
Boul. Cat. Snakes Brit. Mus. 11, 1894, p. 75

***Leptophis liocercus** (Wied)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 114

Liophis typhlus (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 136

Liophis reginae (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 138

***Xenedon colubrinus** Günther
Beebe Coll. Bartica Dist. 1916

***Xenedon severus** (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 149

***Xenedon merremii** (Wagl.)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 150

Aporophis lineatus (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 158

Rhadinaea cobella (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 167

Rhadinaea purpurans (Dum. & Bibr.)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 168

Urotheca bicincta (Hermann)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 184

Dimades plicatilis (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 186

Hydrops triangularis (Wagl.)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 187

Petalognathus nebulatus (Linné)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 294

Atractus torquatus (Dum. & Bibr.)
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 309

Atractus trilineatus Wagl.
Boul. Cat. Snakes Brit. Mus. II, 1894, p. 312

*__Lycognathus cervinus__ (Laur.)
Beebe Coll. Bartica Dist. 1916

Trypanurgos compressus (Daud.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 59

Himantodes cenchoa (Linné)
Schomb. Reise Brit. Guiana III,

*__Leptodeira albofusca__ (Lacép.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 96

Oxyrhopus petolarius (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 102

Oxyrhopus trigeminus Dum. & Bibr.
Boul. Cat. Snakes Brit Mus. III, 1896, p. 104

Oxyrhopus cloelia (Daud.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 109

Oxyrhopus coronatus (Schneid.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 112

Rhinostoma guianense (Trosch)
Schomb. Reise. Brit. Guiana, III, 1848, p. 653

Thamnodynastes nattereri (Mikan.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 117

Thamnodynastes punctatissimus (Wagl.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 117

Philodryas viridissimus (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 129

Oxybelis fulgidus (Daud.)
Schomb. Reise. Brit. Guiana III, 1848

*__Oxybelis acuminatus__ (Wied)
Beebe Coll. Bartica Dist. 1916

Erythrolamprus aesculapii (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 202

***Tantilla melanocephala** (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 216

Apostolepis quinquelineata Boul.
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 235

Family Elapidae

Micrurus surinamensis (Cuv.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 414

***Micrurus psyches** (Daud.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 427

Micrurus marcgravii (Wied)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 429

***Micrurus lemniscatus** (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 430

Family Amblycephalidae

Leptognathus catesbyi (Sentzen)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 449

Leptognathus pavonina (Schleg.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 450

Leptognathus variegata Dum. & Bibr.
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 451

Leptognathus leucomelas Boul.
Beebe Coll. Bartica Dist. 1917

***Dipsas bucephala** (Shaw)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 462

Family Crotalidae

***Lachesis mutus** (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 534

***Lachesis lanceolatus** (Lacép.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 536

***Lachesis atrox** (Linné)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 539

***Crotalus terrificus** (Laur.)
Boul. Cat. Snakes Brit. Mus. III, 1896, p. 575

CLASS: MAMMALIA

Order MARSUPIALIA; **Opossums**

Family Didelphidae

***Didelphis marsupialis marsupialis** Linné
Linnaeus Guiana Opossum; Crab-eating Yawarri
Thomas, Cat. Mar. Brit. Mus. 1888, p. 327

***Metachirus opossum opossum** (Linné)
White-faced Opossum; Quica
Thomas, Cat. Mar. Brit. Mus. 1888, p. 332

Metachirus nudicaudatus nudicaudatus (E. Geoff.)
Bare-tailed Opossum
Quelch, Animal Life in Brit. Guiana, 1901, p. 79

Lutreolina crassicaudata (Desm.)
Thick-tailed Opossum
Thomas, Cat. Mar. Brit. Mus. 1888, p. 336

Caluromys philander (Linné)
Woolly Opossum
Thomas, Cat. Mar. Brit. Mus. 1888, p. 338

***Marmosa murina murina** (Linné)
Linnaeus Mouse Opossum; Little Yawarri
Thomas, Cat. Mar. Brit. Mus. 1888, p. 346

Marmosa chloe Thomas
Chloe's Opossum
Thomas, Ann. Mag. Nat. Hist. (7) XX, p. 167

Marmosa cinerea demerarae Thomas
Demerara Ashy Opossum
Thomas, Ann. Mag. Nat. Hist. (7) XVI, p. 313

***Peramys brevicaudatus** (Erxl.)
Short-tailed Opossum
Quelch, Animal Life Brit. Guiana, 1901, p. 80

***Chironectes minimus** (Zimm.)
Water Opossum; Yapock
Thomas, Cat. Mar. Brit. Mus. 1888, p. 370

Order CHIROPTERA; **Bats**

Family Emballonuridae

Rhynchincus naso (Wied)
Guiana River Bat
Dobson, Cat. Chir. Brit. Mus. 1878, p. 369

***Saccopteryx leptura** (Schr.)
Young, Timehri, (2) X, 1896, p. 44

Saccopteryx bilineata (Temm.)
Thomas, Ann. Mag. Nat. Hist. (7) VIII, 1901, p. 140

Peropteryx canina (Wied)
Thomas, Ann. Mag. Nat. Hist. (7) VIII, 1901, p. 140

Cyttarops alecto Thomas
Thomas, Ann. Mag. Nat. Hist. (8) XI, 1913, p. 136

Family Noctilionidae

Noctilio leporinus leporinus (Linné)
Dobson, Cat. Chir. Brit. Mus. 1878, p. 416

Dirias albiventer (Spix)
Young, Timehri, (2) X, 1896, p. 45

Family Phyllostomidae

Micronycteris megalotis megalotis Gray
Thomas, Ann. Mag. Nat. Hist. (7) VIII, 1901, p. 142

Dolichophyllum macrophyllum Wied
Quelch, Timehri, (2) VI, 1892, p. 97

Phyllostomus hastatus hastatus (Pallas)
Dobson, Cat. Chir. Brit. Mus. 1878, p. 486

Phyllostomus discolor Wagner
Young, Timehri, (2) X, 1896, p. 45

Phyllostomus elongatus Geoff.
Young, Timehri, (2) X, 1896, p. 45

Phyllostomus latifolius Thomas
Thomas, Ann. Mag. Nat. Hist. (7) VIII, 1901, p. 142

Vampyrus spectrum (Linné)
False Vampire
Dobson, Cat. Chir. Brit. Mus. 1878, p. 471

Glossophaga soricina (Pallas)
Quelch, Timehri, (2) VI, 1892, p. 97.

Hemiderma perspicillatum (Linné)
Thomas, Ann. Mag. Nat. His. (7) VIII, 1901, p. 143

Rhinophylla pumilio Peters
Young, Timehri, (2) X, 1896, p. 46

Uroderma bilobatum Peters
Quelch, Timehri, (2) VI, 1892, p. 97

Artibeus planirostris fallax Peters
Anderson, Proc. Zool. Soc. 1908, p. 243

Artibeus cinereus cinereus (Gervais)
Anderson, Proc. Zool. Soc. 1908, p. 291

Artibeus quadrivittatus Peters
Young, Timehri, (2) X, 1896, p. 46

Family Desmodontidae

***Desmodus rotundus** (Geoff.)
Common Vampire; Colony-Doctor
Quelch, Timehri, (2) VI, 1892, p. 97

Diaemus youngi (Jent.)
Young's Vampire
Young, Timehri, (2) X, 1896, p. 46

Family Natalidae

Natalus stramineus Gray
Young, Timehri, (2) X, 1896, p. 44

Family Furipteridae

Furipterus horrens (F. Cuv.)
Thomas, Proc. Zool. Soc. 1887, p. 151

Family Thyroptidae

Thyroptera tricolor Spix
Quelch, Timehri, (2) VI, 1892, p. 97

Family Vespertilionidae

Myotis nigricans (Wied)
Young, Timehri, (2) X, 1896, p. 44

Eptesicus hillarii (Geoff.)
Thomas, Proc. Zool. Soc. 1887, p. 151

Lasiurus borealis borealis (Müll)
Quelch, Timehri, (2) VI, 1892, p. 97

Dasypterus intermedius (H. Allen)
Young, Timehri, (2) X, 1896, p. 44

Dasypterus ega ega (Gerv.)
Quelch, Timehri, (2) VI, 1892, p. 97

Family Molossidae

***Molossops planirostris** Peters
Dobson, Cat. Chir. Brit. Mus. 1878, p. 409

Eumops abrasus (Temm.)
Dobson, Cat. Chir. Brit. Mus. 1878, p. 416

Eumops maurus (Thomas)
Thomas, Ann. Mag. Nat. Hist. (7) VIII, 1901, p. 141

Molossus rufus Geoff.
Young, Timehri, (2) X, 1896, p. 45

Molossus obscurus Geoff.
Quelch, Timehri, (2) VI, 1892, p. 97

Order CARNIVORA; **Dogs, Raccoons, Otters and Cats**

Family Canidae

***Cerdocyon thous thous** (Linné)
Guiana Jungle Jackal; Rough Fox; Crab-dog
Quelch, Animal Life Brit. Guiana, 1901, p. 43

Cerdocyon thous savannarum Thomas
Savanna Jackal
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 146

Icticyon venaticus Lund.
Guiana Hunting Dog; Bush-dog; Warracabra Tiger
Quelch, Animal Life Brit. Guiana, 1901, p. 42

Family Procyonidae

***Procyon cancrivorus** (G. Cuvier)
Crab-eating Raccoon; Crab-dog
Quelch, Animal Life Brit. Guiana, 1901, p. 45

***Nasua nasua nasua** (Linné)
Black Coati; Kibihee; Quashi
Quelch, Animal Life Brit. Guiana, 1901, p. 46

***Nasua rufa** (Ill.)
Red Coati; Kibihee
Quelch, Animal Life Brit. Guiana, 1901, p. 45

***Potos flavus flavus** (Schreber)
Guiana Kinkajou; Potto; Night Monkey
Quelch, Animal Life Brit. Guiana, 1901, p. 46

Family Mustelidae

***Tayra barbara barbara** (Linné)
Guiana Tayra; Galictis; Hacka
Quelch, Animal Life Brit. Guiana, 1901, p. 47

***Grison allamandi** (Bell)
Guiana Grison
Quelch, Animal Life Brit. Guiana, 1901, p. 47

***Pteronura brasiliensis** (Zimm.)
Fin-tailed Otter; Water-dog
Quelch, Animal Life Brit. Guiana, 1901, p. 49

Family Felidae

***Panthera onca** (Linné)
Jaguar; Tiger; Black Tiger; Maipurie Tiger
Quelch, Animal Life Brit. Guiana, 1901, p. 32

***Felis couguar** Kerr
Puma; Deer Tiger
Quelch, Animal Life Brit. Guiana, 1901, p. 36

***Herpailurus jaguarondi unicolor** (Traill)
Guiana Jaguarondi; Hacka Tiger; Eyra
Quelch, Animal Life Brit. Guiana, 1901, p. 38

***Leopardus pardalis tumtumari** (Allen)
Guiana Ocelot; Tiger Cat; Labba Tiger
Allen, Bull. Am. Mus. Nat. Hist. 34, 1915, p. 632

Margay tigrina tigrina (Schreber)
Margay Cat; Wild Cat
Quelch, Animal Life Brit. Guiana, 1901, p. 41

Family Viverridae

Mungos mungo (Gmelin)
Mongoose
[Introduced] Beebe Coll. Georgetown, 1916

Order RODENTIA; **Agoutis, Porcupines, Rats and Mice**

Family Hydrochaeridae

***Hydrochaerus hydrochaerus** Linné
Capybara; Waterhaas; Waterhare
Quelch, Animal Life Brit. Guiana, 1901, p. 28

Family Caviidae

Cavia porcellus guianae Thomas
Guiana Guinea Pig
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 152

Family Dasyproctidae

***Dasyprocta croconota prymnolopha** (Wagl.)
Agouti; Accourie
Quelch, Animal Life Brit. Guiana, 1901, p. 27

***Agouti paca paca** (Linné)
Paca; Labba
Quelch, Animal Life Brit. Guiana, 1901, p. 26

***Myoprocta acouchy** (Erxl.)
Pigmy Agouti; Adourie
Quelch, Animal Life Brit. Guiana, 1901, p. 28

Family Erethizontidae

***Coendou prehensilis** (Linné)
Common Tree Porcupine
Quelch, Animal Life Brit. Guiana, 1901, p. 31

Coendou melanurus (Wagner)
Black-tailed Tree Porcupine
Quelch, Animal Life Brit. Guiana, 1901, p. 31

Family Octodontidae

***Proechimys cayennensis** Desm.
Cayenne Spiny Rat
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 152

Loncheres guianae Thomas
Guiana Spiny Rat
Quelch, Animal Life Brit. Guiana, 1901, p. 31

Family Muridae

Mus musculus musculus Linné
Common House Mouse
[Introduced] Beebe Coll. Georgetown, 1916

Epimys rattus alexandrinus (Geoff.)
Black Rat
[Introduced] Beebe Coll. Georgetown, 1916

Rhipidomys sclateri Thomas
Thomas, Proc. Zool. Soc. 1887, p. 152

Rhipidomys macconnelli de Winton
De Winton, Trans. Linn. Soc. (2), VIII, 1900, p. 52

Rhipidomys nitela Thomas
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 148

Rhipidomys milleri Allen
Allen, Bull. Am. Mus. Nat. Hist. XXXII, 1913, p. 602

Holochilus guianae Thomas
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 149

Nectomys squamipes Brandt
Thomas, Proc. Zool. Soc. 1887, p. 151

Sigmomys savannarum Thomas
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 150

Oryzomys navus messorius Thomas
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 151

Zygodontomys stellae Thomas
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 152

Oecomys rex Thomas
Thomas, Ann. Mag. Nat. Hist. (8), VI, 1910, p. 504

Oecomys nitedulus Thomas
Thomas, Ann. Mag. Nat. Hist. (8), VI, 1910, p. 505

Family Sciuridae

***Sciurillus pusillus pusillus** (Desm.)
Common Dwarf Squirrel
Allen, Bull. Am. Mus. Nat. Hist. XXXIV, 1915, p. 197

Sciurillus pusillus glaucinus Thomas
Grayish Dwarf Squirrel
Thomas, Ann. Mag. Nat. Hist. (8), XIII, 1914, p. 575

***Guerlinguetus aestuans aestuans** (Linné)
Common Jungle Squirrel
Allen, Bull. Am. Mus. Nat. Hist. XXXIV, 1915, p. 257

Guerlinguetus aestuans macconnelli (Thomas)
Macconnell's Jungle Squirrel
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 148

Guerlinguetus aestuans quelchii (Thomas)
Quelch's Jungle Squirrel
Thomas, Ann. Mag. Nat. Hist. (7), VIII, 1901, p. 147

Order EDENTATA; Sloths, Anteaters and Armadillos

Family Bradypodidae

***Bradypus tridactylus** Linné
Three-toed Sloth; Gray Sloth; Ai
Quelch, Animal Life Brit. Guiana, 1901, p. 64

***Choloepus didactylus** (Linné)
Two-toed Sloth; Brown Sloth; Unau
Quelch, Animal Life Brit. Guiana, 1901, p. 67

Family Myrmecophagidae

***Myrmecophaga tridactyla tridactyla** Linné
Guiana Great Anteater; Antbear; Tamanoir
Quelch, Animal Life Brit. Guiana, 1901, p. 73

***Tamandua tetradactyla tetradactyla** (Linné)
Guiana Tamandua; Lesser Anteater
Quelch, Animal Life Brit. Guiana, 1901, p. 74

***Cyclopes didactylus didactylus** (Linné)
Guiana Silky Anteater; Two-fingered Anteater
Quelch, Animal Life Brit. Guiana, 1901, p. 75

Family Dasypodidae

***Priodontes giganteus** (Geoffr.)
Giant Armadillo
Quelch, Animal Life Brit. Guiana, 1901, p. 70

***Dasypus novemcinctus** Linné
Lesser Armadillo; Nine-banded Armadillo; Yesi
Quelch, Animal Life Brit. Guiana, 1901, p. 72

Tatoua unicinctus (Linné)
Small Armadillo; Tatouay
Quelch, Animal Life Brit. Guiana, 1901, p. 71

Order PRIMATES; **Monkeys**

Family Callitrichidae

***Cercopithecus midas** (Linné)
Midas Marmoset
Elliot, Mon. of Prim. I, 1913, p. 191

Family Cebidae

***Alouatta seniculus macconnelli** Elliot
Guiana Howling Monkey; Red Howler; Baboon
Elliot, Mon. of Prim. I, 1913, p. 281

Pithecia pithecia (Linné)
White-headed Saki; Red-bellied Saki
Elliot, Mon. of Prim. I, 1913, p. 294

Pithecia satanas (Hoff.)
Black Saki
Elliot, Mon. of Prim. I, 1913, p. 297

Pithecia chiropotes (Humb.)
Red-backed Saki; White-faced Beesa
Elliot, Mon. of Prim. I, 1913, p. 298

***Saimiri sciureus** (Linné)
Squirrel Monkey; Sackiwinki
Elliot, Mon. of Prim. I, 1913, p. 310

Aotus trivirgatus (Humb.)
Night Monkey
Elliot, Mon. of Prim. II, 1913, p. 16

***Ateleus paniscus** (Linné)
Red-faced Spider Monkey; Quata
Elliot, Mon. of Prim. II, 1913, p. 28

***Cebus apella apella** (Linné)
Guiana Ring-tailed Capuchin
Elliot, Mon. of Prim. II, 1913, p. 80

Order ARTIODACTYLA; **Peccaries and Deer**

Family Tayassuidae

Tayassu pecari pecari Fischer
White-lipped Peccary; Bush-hog; Kairuni
Lydekker, Cat. Ung. Mam. Brit. Mus. IV. 1915, p. 377

***Pecari tajacu** (Linné) subsp.?
Collared Peccary; Black Bush-hog; Abouyah
Lydekker, Cat. Ung. Mam. Brit. Mus. IV, 1915, p. 381

Family Cervidae

Odocoileus virginianus gymnotis (Wieg.)
Orinoco Virginia Deer
Lydekker, Cat. Ung. Mam. Brit. Mus. IV, 1915, p. 174

Odocoileus virginianus spinosus (Gay & Gerv.)
Guiana Virginia Deer
Lydekker, Cat. Ung. Mam. Brit. Mus. IV, 1915, p. 175

Mazama americana americana (Erxl.)
Guiana Red Brocket
Lydekker, Cat. Ung. Mam. Brit. Mus. IV, 1915, p. 202

***Mazama americana tumatumari** Allen
Tumatumari Red Brocket
Allen, Bull. Amer. Mus. XXXIV, 1915, p. 536

***Mazama simplicicornis simplicicornis** (Ill.)
Guiana Brown Brocket; Wellibicirie
Lydekker, Cat. Ung. Mam. Brit. Mus. IV, 1915, p. 211

Blastocerus dichotomus (Ill.)
Marsh Deer; Guazu
Quelch, Timehri, (2) VI, 1892, p. 171

Order PERISSODACTYLA; **Tapirs**

Family Tapiridae

***Tapirus terrestris terrestris** (Linné)
Guiana Tapir; Bush Cow; Maipurie
Lydekker, Cat. Ung. Mam. Brit. Mus. V, 1916, p. 42

Order SIRENIA; **Sea-cows**

Family Trichechidae

***Trichechus manatus** Linné
Manatee; Water Cow; Water Mama
Quelch, Animal Life Brit. Guiana, 1901, p. 58

Order ODONTOCETI; **Dolphins and Whales**

Family Delphinidae

***Delphinus delphis** Linné
Common Dolphin
Quelch, Animal Life Brit. Guiana, 1901, p. 62

Family Platanistidae

Inia geoffroyensis (Blainville)
Guiana Fresh-water Dolphin
Quelch, Animal Life Brit. Guiana, 1901, p. 62

Family Balaenidae

Eubalaena australis (Desm.)
Southern Right Whale
Quelch, Animal Life Brit. Guiana, 1901, p. 62

BIRDS OF BARTICA DISTRICT

ADDITIONAL LIST

At the time of publication of Volume I of "Tropical Wild Life"* the list of birds observed by ourselves or collected by Whitely in Bartica District numbered three hundred and fifty-one forms.

Since then a considerable addition to this list has accumulated from various sources, and these seventy-five new names I now present, bringing the total to the really remarkable number of four hundred and twenty-six different species of birds, all occurring within a radius of ten miles of our Research Station. These lists are, of course, to be considered as merely convenient check-lists, preliminary to the ultimate elaboration of the life histories of the various species.

The number preceding the name corresponds to that in Brabourne and Chubb's "List of the Birds of South America."

183 **Claravis pretiosa pretiosa** (Ferrari-Perez)
Blue Ground Dove

189a **Leptotila verreauxi macconnelli** Chubb
Guiana Rusty Dove

228 **Aramides axillaris** Laur.
Venezuelan Woodrail

238 **Porzana carolina** (Linné)
Sora Rail

255 **Gallinula galeata galeata** (Licht.)
Florida Gallinule

258 **Ionornis martinicus** (Linné)
Purple Gallinule

267 **Heliornis fulica** (Bodd.)
Finfoot

323 **Sterna hirundo** Linné
Common Tern

330 **Sterna superciliaris** Vieill.
Least Tern

*New York Zoological Society, New York, 1917.

375 **Pluvialis dominicus dominicus** (P. L. S. Müll)
American Golden Plover

479 **Tigrisoma lineatum** (Bodd.)
Lined Tiger Bittern

549 **Phalacrocorax vigua vigua** (Vieill.)
Guiana Cormorant

585 **Micrastur brachypterus** (Temm.)
Pied Hawk

586 **Micrastur mirandollei** (Schl.)
Mirandolle's Hawk

591 **Geranospizias caerulescens** (Vieill.)
South American Blue Hawk

597 **Nisus superciliosus** (Linné)
Eye-browed Sparrow Hawk

732 **Ara ararauna** (Linné)
Blue and Yellow Macaw

743 **Orthopsittaca manilata** (Bodd.)
Red-bellied Macaw

869 **Deroptyus accipitrinus accipitrinus** (Linné)
Hawk-headed Parrot

928 **Chordeiles acutipennis acutipennis** (Bodd.)
South American Nighthawk

946 **Hydropsalis schomburgki** Sclater
Schomburgk's Nighthawk

960 **Antiurus maculicaudatus** (Lawr.)
Spotted-tailed Nighthawk

987 **Reinarda squamata** (Cassin)
Fork-tailed Palm Swift

988 **Panyptila cayanensis** (Gmelin)
Cayenne Swift

1001 **Glaucis hirsuta hirsuta** (Gmelin)
Hairy Hermit

1055 **Campylopterous hyperythrus** Cab.
Rufous-breasted Sabre-wing

1082 **Agyrtrina fimbriata fimbriata** (Gmelin)
Lesson's Emerald

1125 **Hylocharis cyanus viridiventris** (Berlep.)
Green-bellied Sapphire

1199 **Chrysolampis elatus** (Linné)
Ruby and Topaz Hummingbird

1288 **Vestipedes vestitus vestitus** (Lesson)
Glowing Puff-leg

1449 **Discosura longicauda** (Gmelin)
Racket-tail

1544 **Pteroglossus acarari atricollis** (P. L. S. Müll.)
Roraima Aracari

1586 **Galbula ruficauda ruficauda** Cuvier
Rufous-tailed Jacamar

1631 **Malacoptila fusca** (Gmelin)
White-breasted Puffbird

1703 **Melanerpes cruentatus** (Bodd.)
Little Black Woodpecker

1749 **Celeus undatus** (Linné)
Waved Woodpecker

1784 **Picumnus spilogaster** Sunde.
Sundevall's Picilet

1799 **Picumnus buffoni undulatus** Harg.
Undulated Piculet

1867 **Taraba major major** (Vieill.)
Great Bush-shrike

1900 **Hypolophus canadensis canadensis** (Linné)
Black-crested Bush-shrike

1992 **Myrmotherula behni** Berl. & Lever.
Behn's Antbird

2096 **Sclateria naevia naevia** (Gmelin)
Surinam Ant-creeper

2493 **Xenops rutilus heterurus** (Cab. & Hein.)
Red-tailed Recurved-bill

2540 **Xiphorhynchus guttatus sororius** (Berl. & Hart.)
Venezuelan Woodhewer

2678 **Mecocerculus leucophrys setaphagoides** (Bonap.)
Bonaparte's Chat-tyrant

2715a **Colonia leuconota poecilonota** (Cab.)
Northern Long-tailed Tyrant

2747 **Platyrhynchus saturatus** Sal. & God.
Guiana Flatbill

2767 **Rhynchocyclus poliocephalus sclateri** Hellm.
Sclater's Flatbill

2829 **Perissotriccus ecaudatus** (d'Orb. & Lafr.)
Short-tailed Pygmy Tyrant

2927 **Tyrannulus elatus elatus** (Lath.)
Yellow-crowned Tyrantlet

2934 **Tyranniscus gracilipes** Scl. & Sal.
Slender-footed Flycatcher

3080 **Myiarchus tyrannulus tyrannulus** (P. L. S. Müll.)
Rusty-tailed Flycatcher

3095 **Myiarchus nigriceps** Scl.
Black-headed Flycatcher

3104 **Tyrannus melancholicus satrapa** (Cab. & Hein.)
Lesser Yellow-breasted Kingbird

3160 **Chiroprion pareola pareola** (Linné)
Blue-backed Manakin

3191 **Scotothorus chrysocephalus** (Pelz.)
Golden-crowned Manakin

3221 **Pachyrhamphus rufus** (Bodd.)
Cinerous Thickbill

3227 **Pachyrhamphus niger cinereiventris** (Scl.)
Grey-bellied Thickbill

3263 **Attila thamnophiloides** Spix
Spix's Attila

3390 **Thryophilus albipectus albipectus** (Cab.)
Schomburgk's White-faced Wren

3498 **Donacobius atricapillus atricapillus** (Linné)
Black-capped Mocking-thrush

3573 **Pachysylvia pectoralis** (Scl.)
Cinereous-headed Woodbird

3617 **Compsothlypis pitiayumi pitiayumi** (Vieill.)
Olive-backed Warbler

3641 **Geothlypis aequinoctialis aequinoctialis** (Gmelin)
Equinoctial Warbler

3645 **Granatellus pelzelni pelzelni** Scl.
Pelzeln's Red-throated Chat

3648 **Setophaga ruticilla** (Linné)
American Redstart

3659 **Myioborus castaneicapillus** (Cab.)
British Guiana Redstart

3678 **Basileuterus roraimae** Sharpe
Roraima Warbler

3713 **Cyanocompsa cyanoides rothschildii** (Bart.)
Rothschild's Blue Grosbeak

3760 **Sporophila americana** (Gmelin)
Gmelin's Seedeater

4076 **Dacnis bicolor** (Vieill.)
Blue-grey Honey-creeper

4138 **Tanagrella velia velia** (Linné)
Blue-bellied Tanager

4281 **Thraupis palmarum melanoptera** (Scl.)
Western Palm Tanager

4361 **Nemosia pileata pileata** (Bodd.)
Hooded Tanager

4437 **Schistochlamys atra atra** (Gmelin)
Black-faced Grey Tanager

The various sources of these additions are as follows:

A—Collected by William Beebe near Kalacoon in 1909 during the expedition described in the volume "Our Search for a Wilderness;"* Numbers 479, 549, 591, 732, 1586, 1631, 1703, and 1784.

B—Collected at Bartica, in Chubb's account of McConnell's collection, "The Birds of British Guiana," Vol. I., together with a manuscript list of those to be published in Vol. II; Numbers 16, 183, 189, 228, 238, 255, 258, 267, 585, 586, 597, 743, 869, 946, 1001, 1055, 1082, 1125, 1199, 1544, 1992, 2096, 2493, 2540, 2678, 2715, 2747, 2767, 2829, 2927, 2934, 3080, 3095, 3104, 3160, 3191, 3221, 3227, 3263, 3390, 3498, 3573, 3617, 3641, 3645, 3648, 3659, 4678, 3713, 3760, 4076, 4138, 4281, 4361 and 4437.

C—Recently identified specimens collected in Bartica District in 1916; 928, 960, 987, 1449, 1749, 1867, 1900, 2715, 3191, 3617, 3645, 3659, 3678, and 4361.

D—Additions made during the short visit to the District in 1917; 323, 330, 375, 629, 836, 988, 1288, 1799, 2927.

LIZARDS OF THE GENUS *AMEIVA* IN BARTICA DISTRICT

NOTES ON THEIR COLOR AND PATTERN VARIATION

Preparatory to intensive studies of the ontogenetic and phylogenetic evolution of color and pattern among neotropical birds, many notes have been made of the remarkable variations found among lizards, especially in such abundant forms as *Ameiva*. While reserving the publication of these until another season's work will have made them more complete, I make mention here of the bearing which color and pattern variation have on the present classification of certain *Ameiva*.

"A Revision of the Lizards of the Genus *Ameiva*" is the title of a very excellent and thorough paper by Thomas Barbour and G. Kingsley Noble.* I wish especially to speak of the forms which the authors recognize as *Ameiva ameiva ameiva*, *A. a. bilineata*, *A. a. melanocephala*, and *A. a. petersii*.

The following quotations have to do with these subspecies:

KEY TO THE SPECIES

i^1 Dorsal surface with heavy confluent spots of black. j^1 Throat sprinkled with a few black spots..*ameiva ameiva*

j^2 Throat smoky. k^1 Brahchials in three rows of subequal scales...... ..*atrigularis*

k^2 Brachials in one row of very large scales and three rows of smaller ones *ameiva melanocephala*

i^2 Dorsal surface with a few black spots not confluent. j^1 A broad lateral band of brown on each side of the adult............ ....*ameiva bilineata*

j^2 Lateral stripe indistinct or wanting....................... ...*ameiva petersii*

HABITAT

Ameiva a. ameiva. Widely distributed over the northeastern part of South America from the Demerara River in British Guiana as far south as Bahia, Brazil, inland along the Amazon to as far west as the Madeira Rive-

Ameiva a. bilineata. Apparently confined to the region between the Demerara and Orinoco Rivers.

Ameiva a. melanocephala. Probably widely distributed throughout Venezuela.

Ameiva a. petersii. Found along the upper Amazon from the Madeira River westward.

*Bull. Mus. Comp. Zool. Harv. LIX. No. 6, 1915, pp. 417-479.

As regards the two subspecies inhabiting British Guiana, the conclusions are based on six specimens, one from Tumatumari and five from Dunoon. The detailed descriptions are from individuals measuring from one hundred and six to one hundred and sixty-two millimeters in length—individuals which I should hardly be inclined to call fully adult. The average of a half hundred specimens collected in one locality I have found to be almost twice this length, while extreme individuals reach over five hundred millimeters.

By a minor geographic error the ranges of the two British Guiana forms are made to overlap, as Tumatumari, the locality for *Ameiva*, is a cataract on the Potaro, a western tributary of the Essequibo, far west of the Demerara and hence well within the indicated range of *bilineata*, "between the Demerara and Orinoco Rivers." Dunoon is on the Demerara River.

The main point I wish to make is that within an area of about five hundred yards around the Research Station of Kalacoon, and within a period of one week, I have collected several score of perfectly typical specimens of *ameiva*, *bilineatus*, *melanocephala* and *petersii;* and others which, judged by still more extreme variation of color and pattern, deserve still further subspecific differentiation. A certain proportion of this remarkable variation is due to age—to ontogenetic pigmental and pattern changes, but, on the other hand, all the forms are represented in my collection by fully adult lizards, that is, by individuals three hundred millimeters or more in length. This extremely local variation would seem to indicate either that all four forms were only intermediate variations, or, rather improbably, that Bartica District is a meeting place for a quartet or more of geographic subspecies. This collection of several score specimens from one locality opens up most interesting questions, and the correlation of observations carried on more widely, should quickly solve these rather superficial problems of diagnostic characters of color and pattern.

The ontogenetic phase can be certainly demonstrated. Young specimens of Bartica *ameiva* averaging one hundred and fifty millimeters in length are almost invariably of an extreme *bilineatus* type, exceeding the description of that form as given by Barbour, in concentration of pigment as much as it in turn is said to differ from *ameiva*. The dorsal and ventral surfaces are immaculate, while a broad black band begins at the snout and extends back to the thigh,

narrowly bordered above and below with blue or white. In about ten per cent. of these small specimens the black body bands are broken up by vertical rows of faint dots.

A second, larger stage, averaging about two hundred and fifty millimetres in length shows black spotting on the throat, and a more decided penetration of the black body bands by the rows of dots. But a new pattern in this phase is a double dorsal series of large black spots, which is found neither in larger nor in smaller forms of this lizard. In my notes I have distinguished this as *bipunctata*.

Passing through larger stages we find a typical lizard of four hundred millimetres in length with much of the upper surface covered with large confluent blotches, and the black lateral bands practically gone, the bluish-white vertical rows of dots of great size, and furnishing the dominant color and pattern note. It has changed from a brown, banded lizard to a green, spotted one. It is nearer to the description of typical *ameiva* than anything else, but lacking such relatively immature characters as the white flank stripe, and the lateral, black, caudal stripe.

Finally, we find a few big bluish-green giants over five hundred millimetres in length, dotted rather than blotched above, and with the lateral green spots large, isolated and framed in black—this framing being all that is left of the broad solid bands which form such a dominant feature in many smaller specimens.

While much more material is needed and will be secured in the near future, yet even in this collection, a hint of still another problem is presented. In all the sizes and color patterns we find occasional individuals which appear melanistic—either in part or as a whole. Thus a specimen which will pass as extreme *melanocephala*, has the entire sides of the head, lower jaw, chin, throat and lower neck to between the forelegs, jet black. This anterior concentration of pigment seems to have been directly at the expense of the dark pigment in other parts of the body. The dorsal and lateral regions are quite green, with the isolated pale lateral dots lacking even their black frame, so drained are all the posterior parts of the animal of their black pigment. It has had a rush of melanism to the head, giving the superficial appearance of a very remarkable pigmented mutation.

A second and more abundant melanistic form goes farther, and while above presenting a dull *ameiva* or *petersii* color and pattern, is

quite uniformly smoky black below. For purposes of record I have called this *melanoventer*.

Studies of the color and pattern variations in living and recently killed specimens; recording of sexual characters in hundreds of individuals, especially of mating pairs; scrutiny of the variations within a single brood of these lizards; uninterrupted observation of ontogenetic changes in individuals from the egg to the five hundred millimetre stage; all these will surely contribute to the solution of such intensely interesting problems as the following:

(a) Are *ameiva, bilineata, petersii, bipunctata, melanocephala* and *melanoventer* recognizable geographic subspecies or variations, which meet and live close together within a few yards radius.

(b) Are they ontogenetic phases of one or more species?

(c) Is it possible that in different localities they combine in part both *a* and *b*; a paedogenetic acceleration or retardation such as we find in Axolotl?

(d) Are these characters environmental or hereditary?

(e) Are the similar variations which Gadow* has so well demonstrated in Mexican *Cnemidophorus* to be considered as parallel or convergent when compared with those of *Ameiva*, in addition perhaps to being a striking instance of orthogenesis?

*A Contribution to the Study of Evolution Based Upon the Mexican Species of *Cnemidophorus*, Proc. Zool. Soc., London, 1906, I, p. 277.

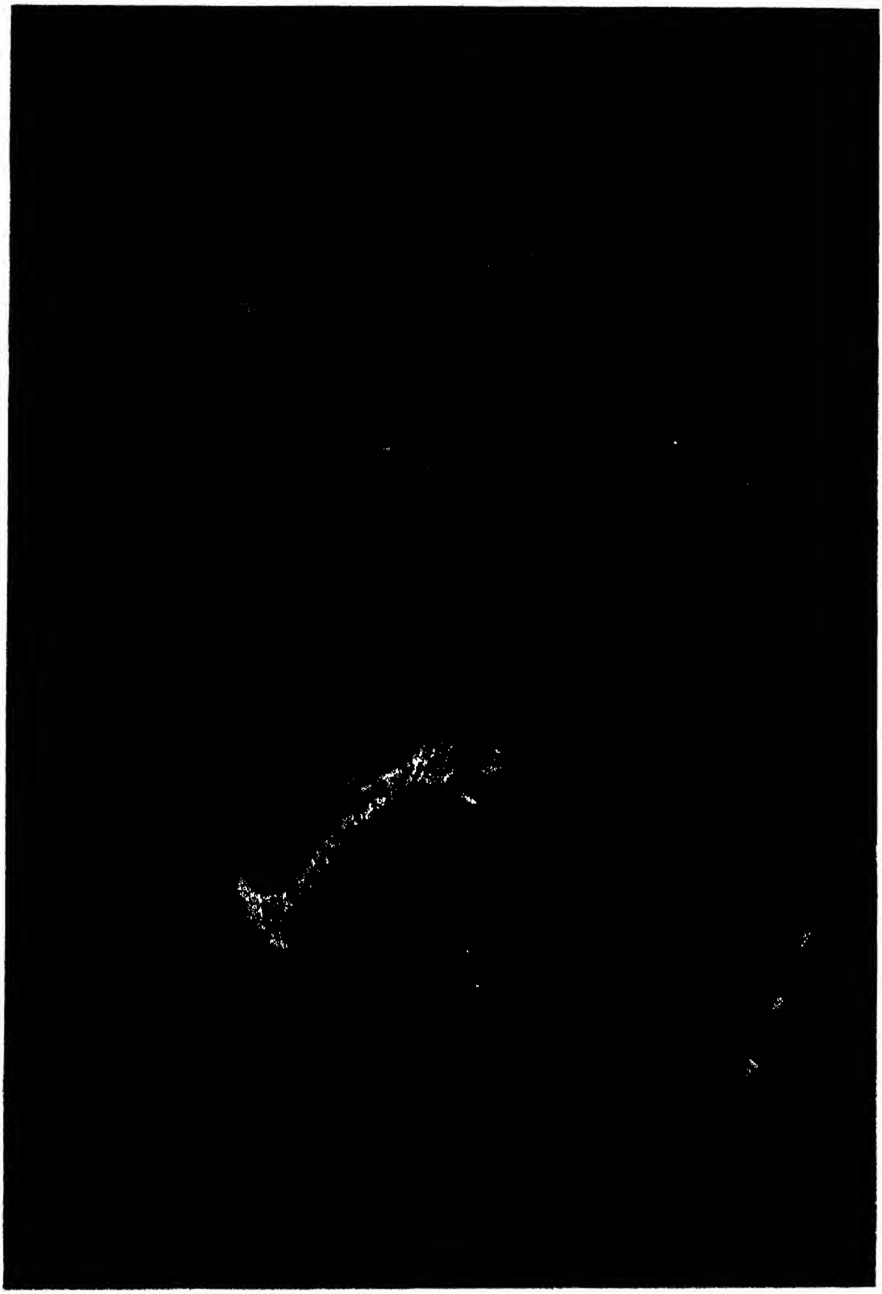


FIG. 69. SAGE GROUSE DISPLAYING AND STRUTTING AT SUNRISE

Painted from Life by R. Bruce Horsfall

ZOOLOGICA
SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBER 10

REMARKABLE HABITS OF THE SAGE GROUSE

AS OBSERVED IN SOUTHEASTERN OREGON IN MAY, 1918

BY R. BRUCE HORSFALL

With Illustrations Drawn from Life by the Author

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

APRIL, 1920

FIGURES

REMARKABLE HABITS OF THE SAGE GROUSE

AS OBSERVED IN SOUTHEASTERN OREGON IN MAY, 1918

BY R. BRUCE HORSFALL

With Illustrations Drawn from Life by the Author

Stealthily and carefully we picked our way along the mud-flat road to the high gate in the lava-rock ranch fence, and peered through the bars.

"There they are!" burst from our lips in an excited whisper, as we caught the glint of white spots a few hundred yards beyond.

Cautiously we clambered over the irregular loose rocks and, like Indians on the warpath, crawled, squirmed and wriggled our way to a low outcropping of volcanic rock. From this vantage point we had an unobstructed view of the broad and bare flood-plain before us.

Cramped and strained in every muscle and bone, we remained hidden among those rocks till supper time, loath to leave the wonderful sight.

In the open at intervals of from twenty-five to fifty feet were sixty magnificent sage cocks strutting around with puffed-out chests and tails spread like miniature turkey gobblers, making noises for all the world like the popping of corks on the pier at Atlantic City, a sound which took me back in memory to the hotel in Colombo, Ceylon, where a hundred guests were served soda water at every meal, and the bottles were always opened at the tables.

Evidently these rocks had been a favorite place for Indians in years gone by, for all about us in the sand were obsidian chips and charcoal, with bits of arrow and spear heads. We afterwards picked up many perfect specimens on the open flat.

Here the Klamath Indian had lurked at evening to secure, with his twanging bow and bits of flying glass, a sage cock for the morrow's dinner, making arrow heads in the middle of the day when no birds were about. To the Indian a strutting sage cock was but an easy mark and a quick lunch. His stolid nature probably did not marvel at the wondrous performance, and no question entered his mind as to how and why.

To us, however, it was a sight which satisfied a great hunger; not the hunger of the body, but of the mind. We had spent days and nights in travel to see that phase of nature, to gain that scrap of knowledge; and we feasted to a great content, though many questions remain unsatisfied as to the how and the why.

The opportunity for these observations had come after two years' delay, and we were accordingly appreciative to the utmost.

In the summer of 1915, we had been viewing the Klamath Lake Pelican Colonies with the game warden, Mr. J. J. Turber, and had gone on to Laird's Landing, at the foot of the lake, to remain over night. While we were there Mr. Laird told us of sage grouse coming down on the flat at the eastern end of the pasture every spring to do their courting, but at that date, May 31st, they had stopped for the season.

It was now May, 1917, and we were to have our opportunity to observe and picture the birds in action.

Mr. Turber had brought William L. Furley, Stanley G. Jewett and the writer from Klamath Falls to Mr. Laird's place. It was afternoon when we rounded the lower end of the lake, and a few grouse were on the open alkali flat. We cached our camera and blind, and went on to the house to arrange for beds and board, leaving as soon as possible for our first close view of the birds. After supper that evening we set up our blind near the grassy slope reaching from the sage-covered hill at the eastern side of "the wash."

The waters that had formed this flood plain came down from the forest-capped Van Brimmer mountain away off to the south. Westward of this wash lay hillocks and ridges of dark lava rock. About eight level acres, near the shore of the lake, were bare of vegetation, and it was there that the sage cocks came from miles around to dance and strut—and "plop."

The strut was made up of four movements. First, the filling of the air pouch, accompanied by a grunting sound; second, a short stiff-legged run in which neither pouch nor wings touched the ground; third, the bird stopped suddenly, spread his tail as it raised to the perpendicular, threw back his head and with a forward movement of the wings pushed the air-filled pouch well up on the chest; fourth, there was a sudden upward throw, followed by a more vigorous and snappy toss, and the tightened pouch came down again on the extended chest with a rubbery "plop." This plop was repeated three times, then the bird eased down for another rumbling gurgle and another run.

Mr. Laird assured us that these antics take place from early March till the first of June; in fact, through the mating season. However, it was evident that this was not a courting action; because when in the course of the morning or evening performance. two or three hens meandered through the throng no notice whatever was taken of them. A real courting performance of a different character may take place in the daytime, far from the watering place, on the sage covered hills.

Each bird appears to have a private spot on which no other dares to trespass. In reaching those proprietary spots, collisions sometimes occurred, and quiet cock-fights took place much after the manner of China pheasants. With rump feathers erect, lowered heads and tails, and dragging pouches, the birds sidled around and struck with their wings; all the while scolding in a trumpeting, gurgling grunt, as the owner actually pushed the intruder off his domain. A few feet one way or another, the belligerents would separate and go on plopping as before.

Some birds began to perform well up in the sage brush, and plopped all the way out to the dancing spot; others walked quietly into their respective claims before beginning to show off.

An examination of the pouch of the sage grouse discloses a peculiar development. In front are two yellowish-green bare spots separated and surrounded by short stiff feathers, shortest and stiffest immediately surrounding the bare area. Probably it is these spots which make the sounding plop, after the manner of a wet drum-head. In the fall, when new, these feathers are soft and exceedingly friable, and by the time the birds are ready for strutting, have broken away to stiff, sharp bristles

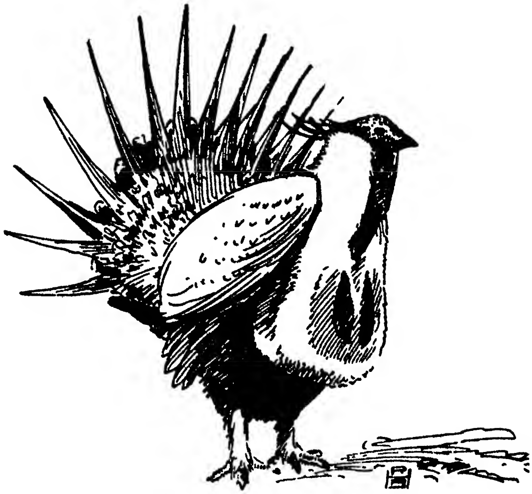


FIG. 70. FILLING POUCH WITH AIR

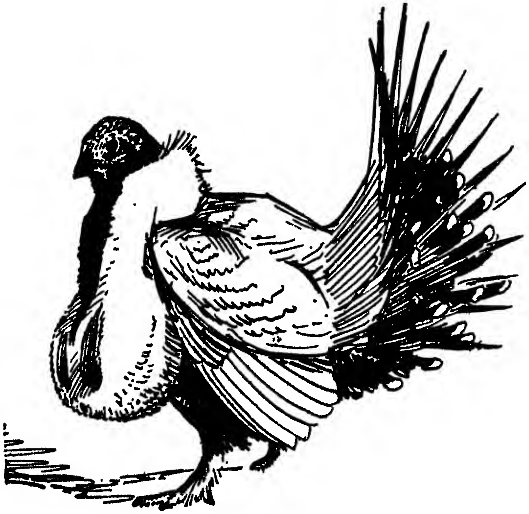


FIG. 71. STIFF-LEGGED RUN AFTER FILLING THE POUCH

STUDIES FROM LIFE OF SAGE GROUSE DANCE
Pen Drawings by R. Bruce Horsfall

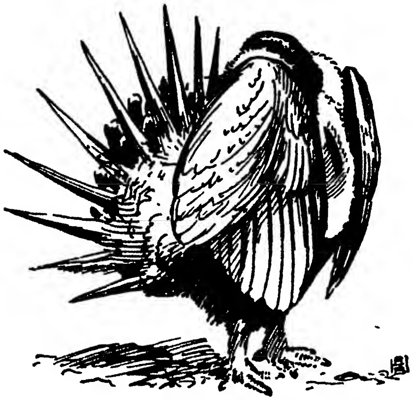


FIG. 72. LIFTING POUCH WITH THE WINGS

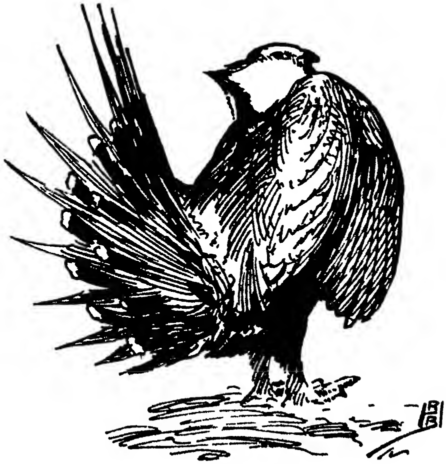


FIG. 73. SIDE VIEW OF LIFT OF THE POUCH

STUDIES FROM LIFE OF SAGE GROUSE DANCE
Pen Drawings by R. Bruce Horsfall

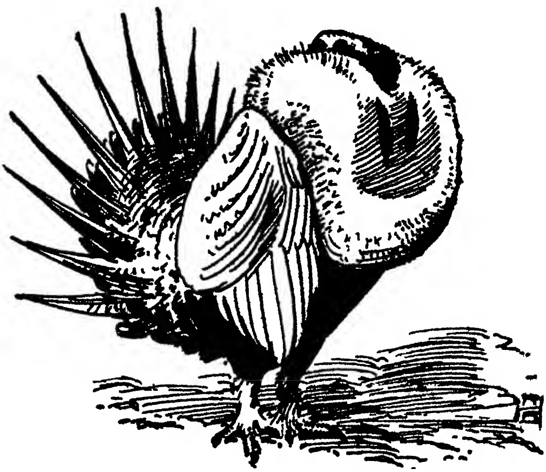


Fig. 74. Extreme of Throw of the Pouch

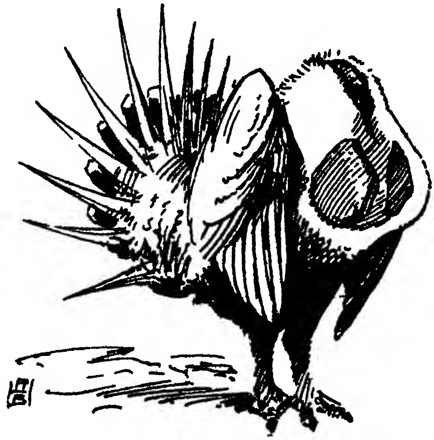


Fig. 75. Slap Down of Pouch on Chest Showing Distended Bare Spots.

STUDIES FROM LIFE OF SAGE GROUSE DANCE

Pen Drawings by R. Bruce Horsfall

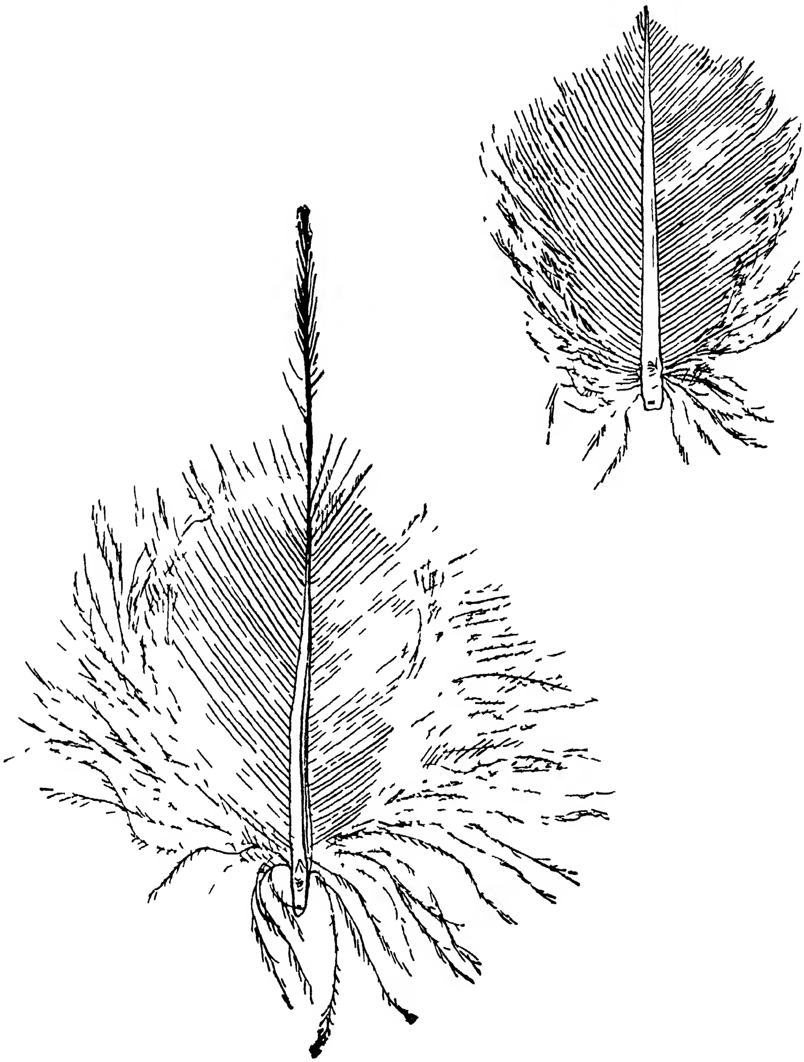


FIG. 76. SAGE GROUSE (MALE) NECK FEATHERS

September feather of loose structure which accounts for the wear on the spring feather. *Upper*—Taken from near bare spots on the pouch. *Lower*—Feather from breast beneath pouch

Pen Drawings by R. Bruce Horsfall

which will in no way interfere with the vigor of the snap, as soft feathers would do.

The morning after our arrival, the 11th of May, no birds came near enough to the blind for photographing. At nine o'clock it began to rain, and we spent the remainder of the morning searching for nests on the adjacent hillside. We found two from which the young had hatched, and one that had been rifled of its contents, probably by a coyote. In the afternoon the birds came in too late for pictures.

On May 11, no birds came near the blind, so we moved it to another spot. The afternoon was windy and stormy, and only a few birds came in at four o'clock.

On the 13th of May, we arose at three A. M. and after a hurried breakfast, stumbled and wabbled along the ruts of the road. No wind was stirring; which was a very unusual thing for this high plateau region. A heavy cloud hung over us, as only clouds in an arid region can hang, black as night, but the faint yellowish light of dawn was slowly brightening as we crept into the blind, at four o'clock. Dark as it was, a few birds were already there, and by five-fifteen we were able to make the first exposure. As usual, there were about sixty birds in the field. Actual counts of birds within our range of vision at various times were 51, 52, 51 and 54. By seven o'clock all had left for the sage-brush hills; but we had had several birds within thirty feet of us most of the time.

We returned to the blind at 4:15 A. M. A few birds were on the shore when we arrived and by seven o'clock, the usual time for the birds to scatter, we had secured moving and still pictures of every action from birds within twenty-five feet of us.

As we left, a lone coyote yapped to us a long farewell.

FIG. 77. GAME COCK, SHOWING HACKLE IN ECLIPSE

FIG. 78. Left RED JUNGLE FOWL (*Gallus gallus*) SHOWING HACKLE IN ECLIPSE
Right: RED JUNGLE FOWL (*Gallus gallus*) SHOWING FULL HACKLE

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBER 11

ECLIPSE PLUMAGE IN DOMESTIC FOWL

By

LEE S. CRANDALL
CURATOR OF BIRDS

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

OCTOBER 15, 1920

ECLIPSE PLUMAGE IN DOMESTIC FOWL

By Lee S. Crandall
Curator of Birds.

From the time of Darwin, ornithologists almost unanimously have agreed that the Red Jungle Fowl (*Gallus gallus*) of India, the Malay Peninsula, Indo-China and the neighboring islands, is the sole ancestor of domestic fowls. Practical poultrymen, on the other hand, are equally sure that certain breeds, especially of the groups known as Asiatics and Oriental games, must have come from some unknown, gigantic ancestor. There are some, also, who feel that the case of the Red Jungle Fowl's ancestral relation to breeds other than these Eastern types, is not fully established. While it is not the purpose of the present paper to enter fully into this discussion, it is felt that the facts herein presented have a strong bearing in this seemingly interminable controversy.

On October 22, 1916, the New York Zoological Park received, through the medium of Ansel W. Robinson, of San Francisco, a pair of Red Jungle Fowl. They were young birds but the male was in full color, with flowing hackle and saddle feathers. The pair had been obtained in the Philippine Islands, where the species is believed to have been introduced by man. Both specimens were typical, which is more than can be said for most of the Red Jungle Fowl seen in captivity. They were very wild when first received but gradually became tamer, though they never would allow themselves to be handled or even touched.

The birds were kept in warm quarters during the winter months, and by spring were in very good feather and condition. In June, the cock began to shed his long neck hackles and dropped the sickle feathers of the tail at the same time.

Close watch was kept on the bird during this period and it was found that he was going through the oft-mentioned but seldom described eclipse which is typical of the species. As the red, black-centered, pointed hackle feathers dropped out, they were replaced by short, round-tipped black ones. Those in the upper portions of the neck were broadly margined with orange, but as they approached the neck, they became wholly black.

Late in July, the cock caught a sudden cold, and died on August 2, 1917. The eclipse was not quite complete, the small

feathers on the head, just behind the comb, not having been molted. It is quite possible that this is as far as the normal eclipse goes. The new tail sickles had not yet begun to grow. This individual seems to correspond in general with Ogilvie-Grant's* designation of June-September as the eclipse period.

This eclipse plumage of the male Red Jungle Fowl, while not generally well known, has always proved a stumbling block to those who maintain that the species is the sole ancestor of our domestic fowl. It has been difficult to explain the absence of the eclipse in domestic birds, since it is so characteristic of their wild progenitors.

There seems to be no record of eclipse plumage in domestic cocks, though in the light of the present evidence, this seems due rather to oversight than to lack of occurrence.

In the autumn of 1919, Mr. Prescott Van Wyck, of Summit, New Jersey, brought to the Zoological Park, a Black-breasted Red Pit Game cock, for the writer's inspection. The bird was a yearling, in his first adult molt. Examination showed that the sickle feathers of the tail had been cast and that the neck was in eclipse plumage, exactly as in the Red Jungle Fowl. This is all the more interesting, as, in color, the Black-breasted Red game fowl is an almost perfect counterpart of the Red Jungle Fowl. The eclipse feathers of the game cock were orange, with broad black margins, exactly the opposite of the colors in the Jungle Fowl eclipse. To complete the comparison, the short, red, pointed feathers of the head, as in the Jungle Fowl, had not been replaced.

Unfortunately, this cock was not the property of Mr. Van Wyck, and could not be left for observation. However, a photograph was made, showing the hackle in eclipse. In the foreground of the photograph, which is presented herewith, a single unmolted hackle feather may be seen.

A few months later, the change to full plumage had been accomplished, and specimens of the normal hackle feathers were obtained, which may be compared with those of the eclipse.

It seems reasonable to suppose that this example of the eclipse plumage in domestic fowls, is not unique but that its occurrence has been overlooked. Careful examination of molting cocks, particularly game fowl, no doubt would reveal total or partial eclipse plumage as at least fairly common.

*Ogilvie-Grant, W. R. A Hand-book of the Game Birds, 1897, Vol. II, pp 48-9.

FIG. 79. Above FEATHERS FROM ECLIPSE HACKLE OF GAME COCK
Below. NORMAL HACKLE FEATHERS FROM SAME BIRD

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II. NUMBER 12

(Papers from the New York Aquarium)
(Contribution Number 5)

A CONTRIBUTION TO THE LIFE HISTORY OF THE PUFFER, *SPHEROIDES MACULATUS* (SCHNEIDER)

By W. W. WELSH
United States Bureau of Fisheries
AND
C. M. BREDER, JR.
New York Aquarium

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

JANUARY, 1922

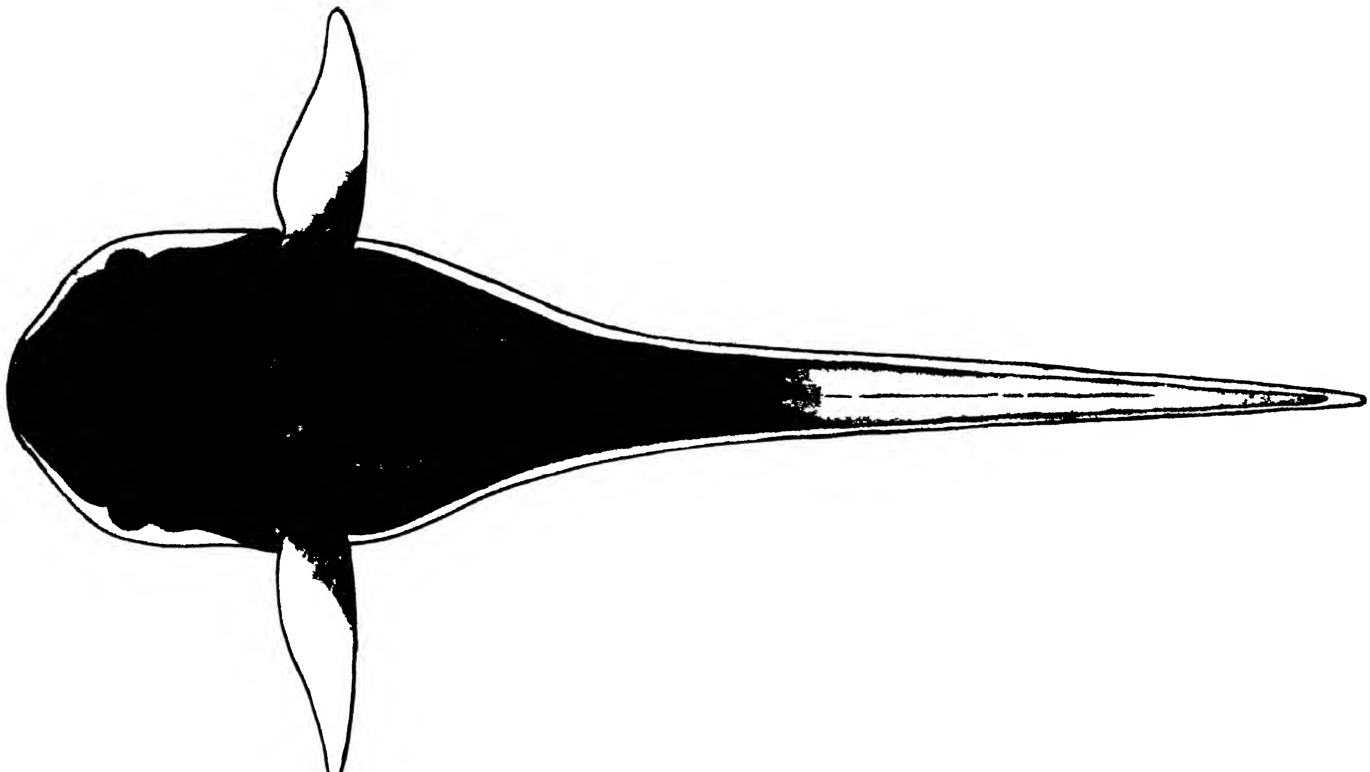


FIG 80. LARVA FIVE DAYS AFTER HATCHING
Actual length, 2.55 mm.

A CONTRIBUTION TO THE LIFE HISTORY OF THE PUFFER, *SPHEROIDES MACULATUS* (SCHNEIDER)[1]

By W. W. Welsh
United States Bureau of Fisheries

C. M. Breder, Jr.
New York Aquarium

Introduction.

The present paper embodies the results of studies on *Spheroides maculatus* (Schneider), carried out at Atlantic City, New Jersey, chiefly during the month of August, 1920, where a temporary field laboratory was established on Young's Million Dollar Pier through the courtesy of Captain E. L. Young. All material for study was obtained from the two pound-nets operated upon this pier.

The temperature of the water during this season was abnormally low, being comparable to that normally encountered below the five fathom line in this region. Although conditions in general were rather unsatisfactory for this type of work, no difficulty was encountered in securing adequate material for the study of this species.

The drawings of the eggs and larvae were made from living material by means of the camera lucida. In most cases a small quantity of chlorotone was added to the sea water containing the larvae, to quiet them. All illustrations, excepting Fig. 87 have been executed by the junior author.

[1] Published by permission of the United States Commissioner of Fisheries.

Ontogeny.

Spawning.—Ripe females of this species were taken from July 30 to August 27, which were the first and last dates on which specimens were examined. There seemed to be no increase or decrease in the proportionate number of ripe fish, which fact suggests that the peak of their sexual activity extends well over the period in this region. Hard and spent individuals were constantly taken with the ripe ones. The ova passed freely on the application of very slight pressure, issuing forth in a stream about 3 mm. in diameter. Ripe males were frequently taken, but equal success in fertilization was obtained by macerating the testes of fish from which milt would not flow. The sexes were present in approximately equal numbers.

Eggs.—The eggs are transparent, spherical, and invested with a smooth adhesive covering which is irregular in outline. They are demersal and readily become attached to any submerged object, or caked in a mass, owing to their adhesive nature. Where numbers adhere to a side of the container, close together and in a single layer, the adhesive envelope assumes a somewhat hexagonal appearance. The surfaces of the eggs are finely reticulated, rather resembling crepe paper. The eggs average about 0.874 mm. in diameter, varying from .85 to .91 mm., while the enveloping adhesive coat increases the diameter to an average of about .954 mm. A large number of colorless oil globules of low refractive index are present in a foamy cluster, which averages about .34 mm. in diameter, and a very faint yellowish olive tinge can be detected in the area in which the blastoderm is to develop. Fig. 81, A represents the unfertilized egg.

Embryology.—The eggs, of which the development was studied, were incubated in small bowls, with a daily change of water, at a temperature which averaged about 67°F. At fifteen minutes after fertilization no great change was apparent, but within the following two hours the first cleavage had been completed (Fig. 81, B), and by sixteen hours after fertilization the blastodisc had commenced to indicate the approaching differentiation (Fig. 81, C). By twenty-four hours the embryo was quite

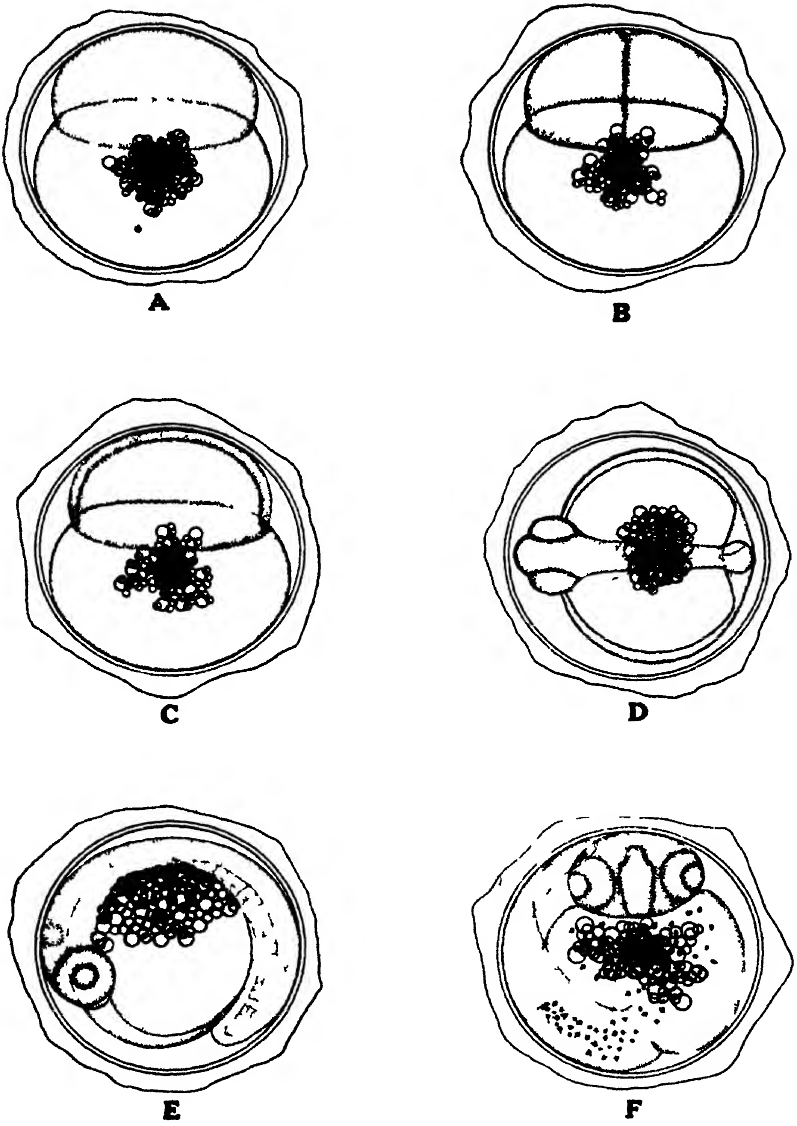


FIG 81. MAGNIFICATION 36 X

A—Unfertilized egg. B—Egg with blastoderm of two cells. Two and one-half hours after fertilization C—Egg showing early stage in the differentiation of the embryo. Sixteen and one-half hours after fertilization. D—Egg showing a moderately advanced stage of differentiation of the embryo. Forty hours after fertilization. E—Egg with moderately advanced embryo. Seventy hours after fertilization F—Egg with advanced embryo. Ninety hours after fertilization

distinct and in the succeeding twenty it had reached more than half way around the yolk (Fig. 81, D) At seventy hours the tail was free at its tip, vertebral somites were visible, and convulsive squirmings had commenced. Scattered black chromatophores had appeared along each side and the eyes were quite distinct. The oil globules were chiefly located in the dorsal half of the yolk (Fig. 81, E). At ninety hours, in addition to the black chromatophores, red and orange ones were scattered along the sides. The anterior ventral surface of the yolk was well covered with large black chromatophores, rather dendritic, and there was a suggestion of the oil globules consolidating into a somewhat lesser number of larger spheres. A few small black chromatophores and punctulations were located in the posterior part of the iris and on the tip of the snout (Fig. 81, F). At this stage the tip of the tail overlapped the head and the embryo exhibited much activity. The eggs began hatching at about one-hundred and twelve hours after fertilization. At this time they were steadily increasing in pigment content. The pigmentation terminated posteriorly in abrupt fashion about midway between the vent and the tip of the tail, and at this point a brilliant opaque chrome yellow spot was apparent on the dorsal surface. Numbers hatched however before the chrome yellow spot appeared (Fig. 82). Most of the larvae emerged from the egg tail first, although in a few cases the head came first. Both the eggs and larvae were decidedly variable during the entire period they were under observation, especially in the matter of pigmentation.

The frontispiece (Fig. 80) represents the typical coloration of the fry at the age of five days. Various shadings have been used in the text figures in an attempt to represent the very striking coloration exhibited by this species. Red has been represented by large closely placed dots, yellow by small ones, and the various green, orange, and purple markings by short lines, the location of each being explained in the text. By comparing the line drawings with the colored plate, a fair idea of the pigmentation at each stage may be gained, since, while the amounts of pigment present in the various stages differ, the actual colors shown by the chromatophores differ little from those represented in the plate.

Larval development.—The newly hatched larvae averaged about 2.41 mm. in length. The yolk sac was small and still contained oil globules. The head was somewhat deflected and the eyes, the pupils of which were not yet dark, were directed a trifle forward and downward. The pectoral fins were difficult to see, owing to the heavy pigment lying beneath them. The coloration was brilliant; red, orange, yellow and black chromatophores being thickly distributed over the body. Deep purplish black chromatophores invested the anterior end of the yolk sac and some were scattered through the iris, which also contained a cluster of heavy black ones in the dorsal and posterior quadrant. Numerous minute tubercles were present over practically the entire body. The newly hatched larvae were very active and possessed considerable vitality. Fig. 88 shows a detailed profile of the head at this age.

As development advanced the red pigment became relatively reduced, the orange and yellow coming more into prominence. About twenty-four hours after hatching the pupil became black, the nostrils were plainly visible, the pectorals more distinct, and what seemed to be beginnings of lateral line organs had appeared. Seven pairs of these organs were observed in a two day old specimen, and probably more were present but not distinguishable from the surrounding tissue. Three pairs have their origin over the eyes, a small and a large pair are posterior to the pectorals and another small pair over the vent, as well as a pair somewhat forward of that point (Fig. 83). On treating one specimen with chlorotone a secretion appeared to exude from these bodies, which indicated their glandular nature. Fig. 89 shows in detail the vent and location of the two posterior glands, and Fig. 90 represents the appearance, in profile, of the large one just behind the left pectoral in a specimen seven days old.

At two days the vent and mouth were open, and in addition to the other pigments, various green markings had appeared, especially in the iris. The yolk was materially reduced and at three days the mouth was functioning. Viewed by reflected light the colors were brilliant and metallic. The fry were active and decidedly heliotropic. The chrome yellow caudal spot, pre-

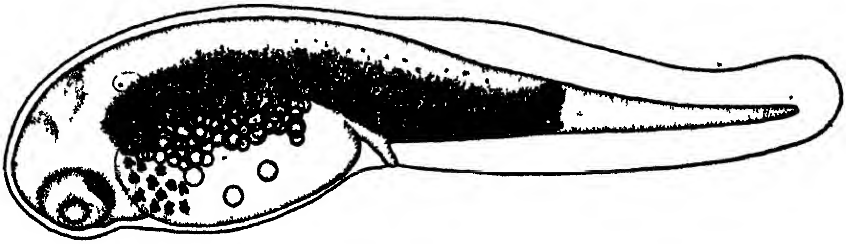


FIG. 82. NEWLY HATCHED FISH.
Actual length, 2.41 mm.

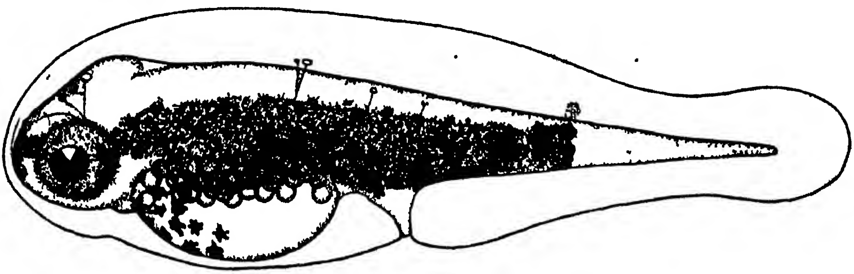


FIG. 83 LARVAL FISH ONE DAY AFTER HATCHING.
Actual length, 2.50 mm.

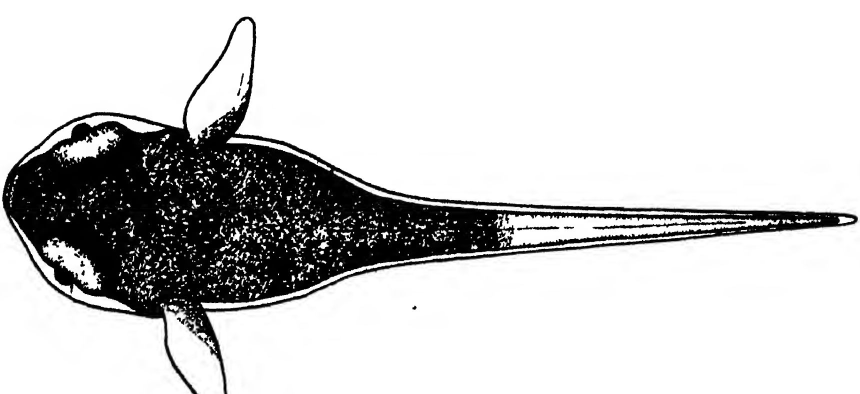


FIG. 84. LARVAL FISH FIVE DAYS AFTER HATCHING.
Actual length, 2.55 mm.

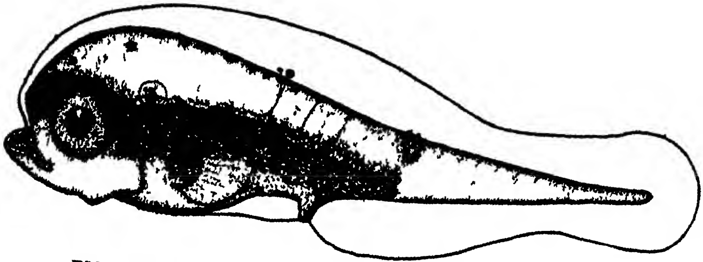


FIG 85 LARVAL FISH SEVEN DAYS AFTER HATCHING.
Actual length, 2 62 mm.

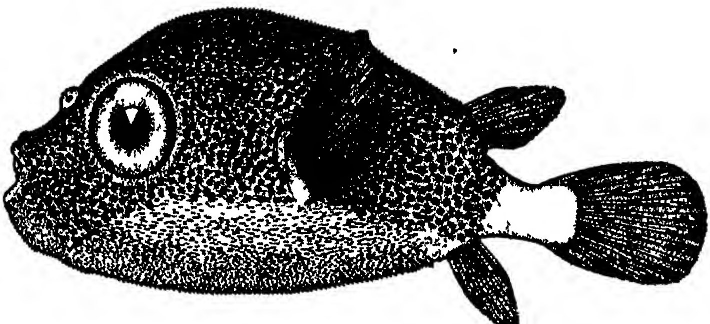


FIG 86. POST LARVAL FISH
Actual length, 7 35 mm

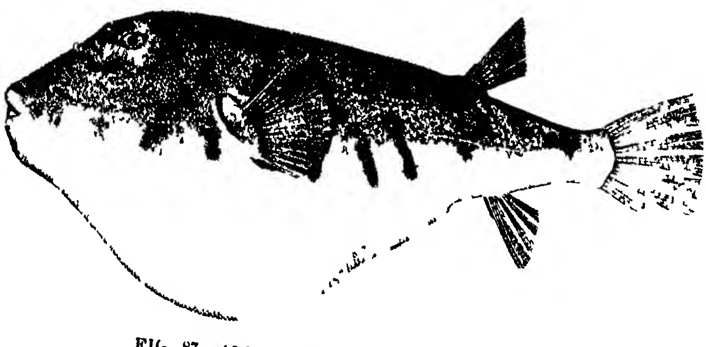


FIG 87 ADULT FISH, PARTLY INFLATED
Actual length, 200 mm.

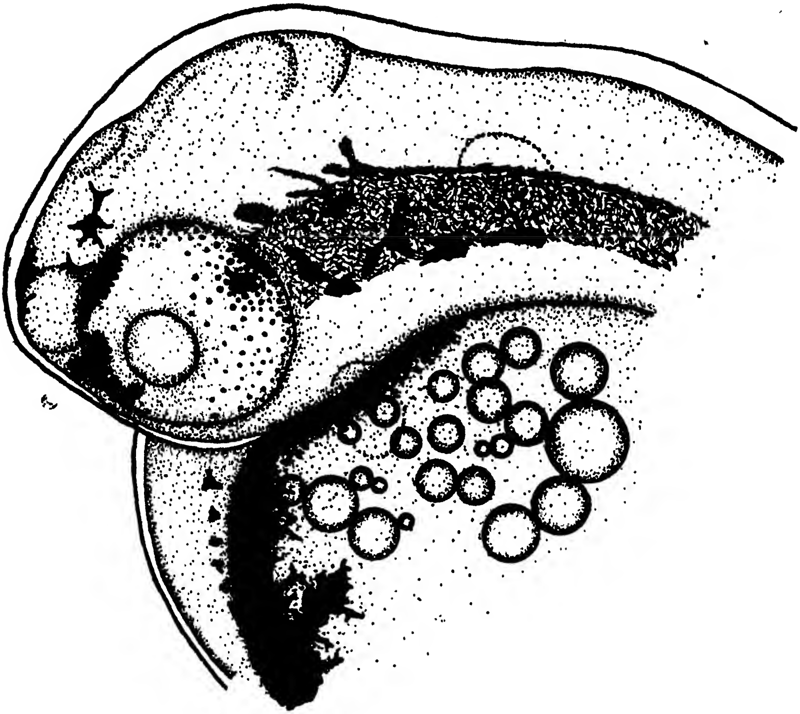


FIG. 88. DETAIL OF HEAD OF NEWLY HATCHED LARVA.
Actual length of entire fish nearly 2.40 mm.

viously noted, and a few black ones on the head constituted the only dorsal pigments.

On the fifth day numerous tubercles of considerable size were observed on the ventral surface. The eyes were coming into a more nearly lateral position and a small spine was developing on the operculum. The black chromatophores on the abdominal region (the yolk being practically absorbed and the oil globules gone) were decidedly dendritic. The pectoral was assuming a less spatulate shape, a rather pronounced point appearing near the upper margin, and the maxillary was well formed and prominent (Fig. 84). The tip of the tail, shown by Fig. 91, indicates the tuberculated appearance of the body in a six day old specimen. At this age the otoliths were becoming

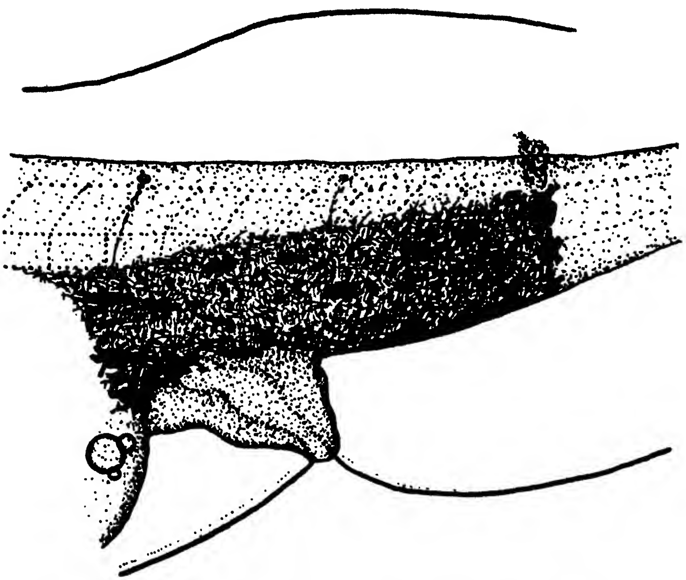


FIG. 89. DETAIL OF VENT OF TWO DAY OLD LARVA.
Actual length of entire fish nearly 2.52 mm.

more complicated in conformation and the body was becoming opaque. At seven days, (Fig. 85), little further change in appearance could be observed. The tubercles, especially on the ventral surface steadily increased in size, and the maceration of some from that location disclosed small barbed hooks as shown in Fig. 92. At ten days the larvae were all dead or dying, the largest having reached a length of 2.65 mm.

It is believed that these eggs and larvae would prove exceptionally satisfactory for detailed studies of embryology and larval development; the eggs, because of extreme hardihood, transparency, and possession of an adhesive coat maintaining them in a definite position; and the larvae because of the large and varied chromatophores that develop so strikingly, and their great tenacity to life.

Fig. 86 was drawn from a specimen 7.35 mm. long taken by the U. S. S. Grampus July 31, 1913, station No. 10081, over a depth of eleven fathoms off the New Jersey coast near Barnegat, the net haul being from ten fathoms to the surface. At this stage most of the diagnostic characters of the adult have been

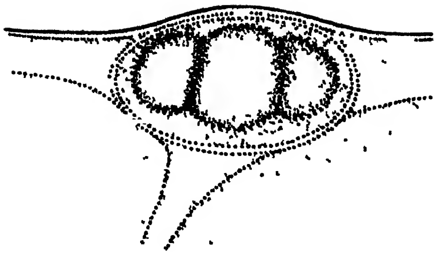


FIG. 90 PROFILE OF LATERAL ORGAN, POSTERIOR OF LEFT PECTORAL FIN, FROM A SEVEN DAY OLD LARVA.
Magnification nearly 360 X.

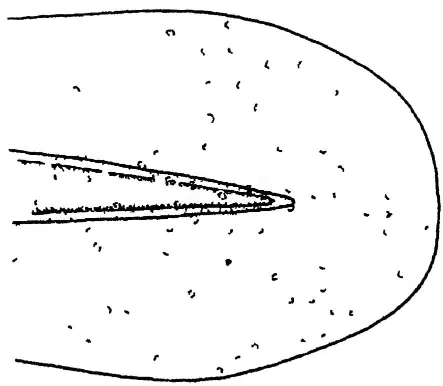


FIG. 91. TIP OF TAIL OF SIX DAY OLD LARVA SHOWING TUBERCLES.
Magnification nearly 104 X.

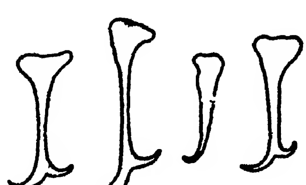


FIG. 92. SPINES FROM VENTRAL SURFACE OF TEN DAY OLD LARVA.
Magnification nearly 360 X.

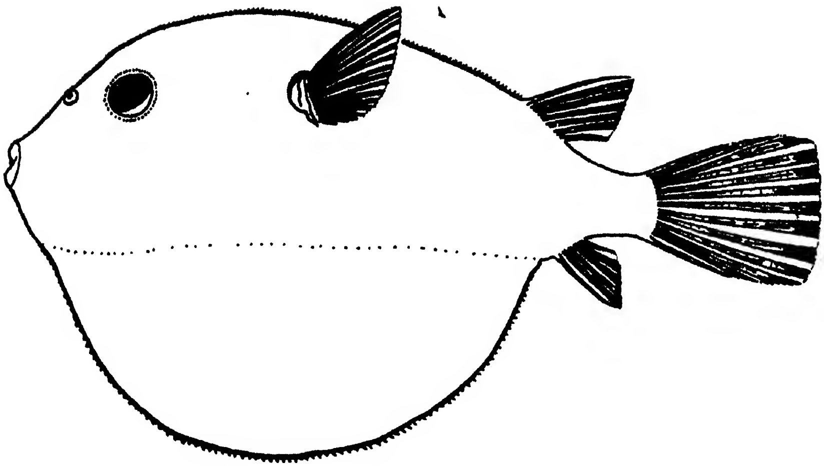


FIG. 93. OUTLINE OF A SPECIMEN 22.5 MM. LONG, SHOWING PROPORTIONS ASSUMED ON INFLATION BY THE POST LARVAL FISH.

From United States National Museum collection. Aug. 11, 1892, Quissett Harbor, Mass.

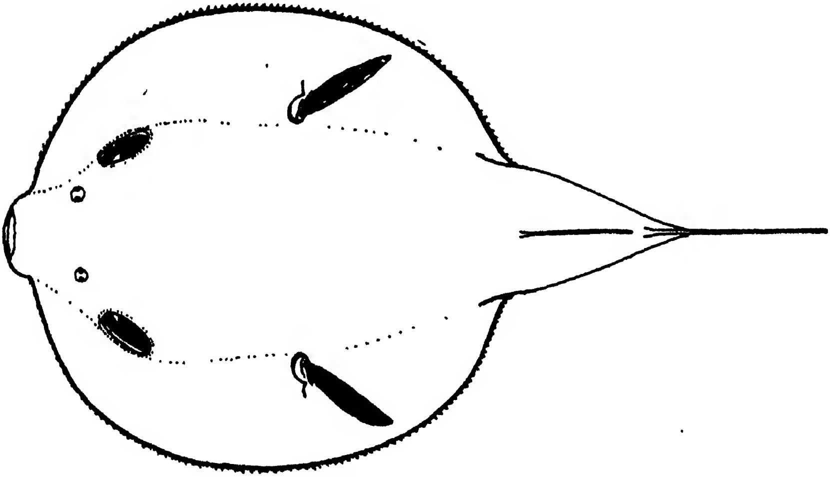


FIG. 94. DORSAL VIEW OF SPECIMEN SHOWN IN FIGURE 93.

acquired, although the skin surrounding the body is more distensible than in the mature fish. The transparent membranes covering the eyes move away from them on inflation, adding to the grotesqueness of appearance. The skin is literally turned inside out over the caudal, dorsal and anal fins, the fish inflating to such an extent that these fins are buried in furrows in the distended skin. In preserved specimens the dorsal outline over the eye is extended by a fold of this expansive membrane, which shows in the deflated specimen illustrated by Fig. 86. The projecting pectorals are practically the only prominences of note on the otherwise spherical surface of an inflated specimen. As shown in Figs. 93 and 94, by the time the species attains a length of 22.5 mm. their inflatibility does not exceed that of the adults. The entire skin, however, is still loose, and upon inflation, as the drawing indicates, the membrane covering the eye becomes pulled down to a certain extent.

Latham, 1916[2], reports having seen specimens 2.5 to 7.5 cm. at Orient, Long Island, during November and the early part of December. It may be inferred that the smaller ones at least must have been hatched that same year, when it is considered that specimens of over 7 mm. were taken in July by the Grampus. This, together with the fact that specimens in graduated sizes from a few mm. in length to adult size have been taken at most diverse seasons, indicates a long spawning season.

Preserved material.—Examples of all stages studied were preserved in strong formalin. The most notable change in the younger eggs was the change of the oil globules to a decidedly amber color, and their migration from the interior of the yolk to its outside wall, at which surface they mostly adhered. The blastodisc and the early embryos became white and opaque. All chromatophores lost their color and were difficult to differentiate, excepting the black ones. The prominent chrome yellow spot nearly disappeared, and the lateral glands were almost indistinguishable. Staining with alizerin red failed to aid much in bringing out these details.

---

[2] Latham, Roy—Migration notes of fishes from Orient, Long Island. Copeia, March 24, 1916, No. 41, p. 22.

Food.

The stomachs of 102 specimens taken between July 30 and August 4 were examined immediately on capture. The range of total lengths was from 14 to 24 cm. Some individuals were spawned out, others still hard, although the majority were ripe. No variation in diet could be correlated with size, sex or condition. The males were fifty-nine in number and the females forty-three.

The accompanying table indicates the number of stomachs containing each constituent of their food.

Material	Number of stomachs.
Small crabs	14
Unidentified crustaceans	2
Mussels	7
Univalves	1
Unidentified	82
Empty	16

The crabs were all of small non-commercial species. The unidentified material consisted largely of matter reduced to an offensive blue or yellowish paste. The apparent discrepancy in numbers is accounted for by the fact that some specimens partook of more than one kind of food.

Linton, 1905[3], found on examining fifteen specimens during July and August at Beaufort, N. C., that their food included fragments of oysters, scallops, mussels, razor-clams, gasteropods, barnacles, crabs, shrimp, sea-urchins, worms, ascidians, bryozoans, and watermelon seed, which gives the species a much more varied diet than found in the present investigation.

Relative Size of the Sexes.

The females of this species average somewhat larger than the males. Inspection of Fig. 95 shows that there is a difference of 3 cm. between the modal lengths of the two sexes. The

[3] Linton, Edwin.—Parasites of the fishes of Beaufort, N. C. In Bulletin, U. S. Bureau of Fisheries, Vol. XXIV, 1904, p. 402.

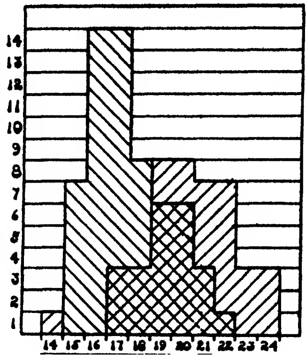


FIG. 95.

Horizontal index—Total lengths in centimeters. Vertical index—Number of individuals. Males represented by hatching from upper left to lower right corner. Females represented by hatching from upper right to lower left corner.

difference of the averages is slightly less, being about 2.85 cm. The 102 specimens examined for food determination were measured for plotting this graph. It is evident that fish more than 22 cm. long are almost surely females, while those less than 17 cm. are nearly all males. The sole female of 14 cm. length was probably a large specimen of a younger group, the remainder of which probably passed through the meshes of the net or were chiefly located in another area.

This knowledge proved very useful when dissecting the fish for eggs and milt, as by simply selecting the largest and smallest examples of a catch, both sexes could be had with almost entire certainty.

While both gonads were functioning in ripe fish, in all cases the left one was considerably larger than the right.

THE RELATION OF LENGTH TO WEIGHT.

The total lengths and weights of the 102 specimens of both sexes formed the basis of Fig. 96 which is arranged to show the weight of a fish of any given length or vice-versa. These are plotted against each other, the larger circles indicating the points obtained by averaging the weights of all specimens in their respective length groups, which are in steps of 1 cm. The small circles on either side of the large ones indicate the high-

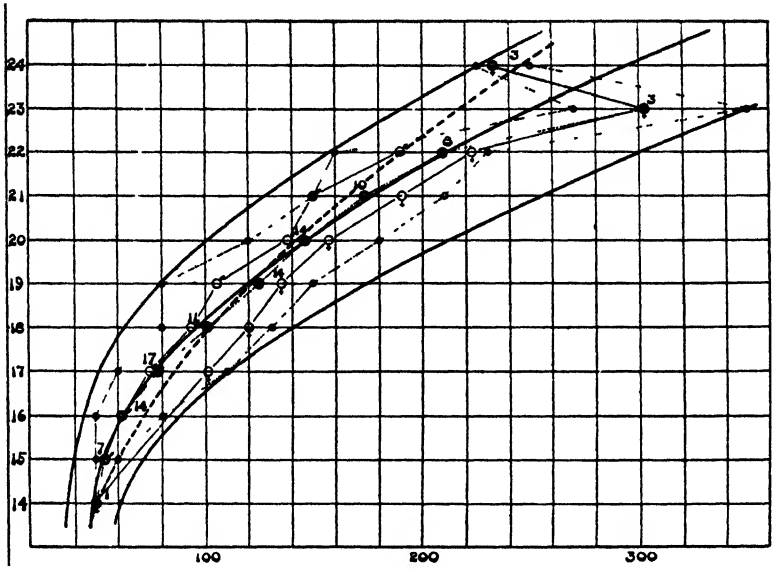


FIG. 96.

Horizontal index—Weights in grams. Vertical index—Total lengths in centimeters. Large circles—Average weight of corresponding length group. Small circles—Extremes in weight for corresponding length group. Numbers near large circles—Number of specimens making up average. Sex symbols—Average weight of sex indicated for corresponding length group. Center heavy curve—Line of average weights, smoothed. Outer heavy curves—Lines of extreme variation of weights. Heavy dashed curve—Line of formula, $w=l^3/36$.

est and lowest weights found in the individual groups. The central heavy curved line is the theoretical curve obtained by smoothing the dotted line connecting the large circles. It graphically represents the change in relation of length and weight as growth increases. The two outer heavy curved lines represent the limit of individual variation as established by the plotted points. The sex symbols connected by light solid lines shows the average weight for the indicated sex in each length group. This shows well the fact that males weigh considerably less than females of a given length. The modal weight of the males is about eighty-two grams less than that of the females, while the difference of the average weights is about eighty-seven grams.

It is evident that having the length or weight of a fish of this species, the other may be had by inspection of the curve,

the central lines giving the probable measurement, while the outer two limit the known variation in the breeding season. If the specimen in question is a male its weight will in all probability fall between the central line and the left hand outer one, while if it is a female it will probably be located on the other side of the central line.

On the assumption that the weights of fish of this species vary as the cube of their length multiplied by some constant, as is usual in fishes, the formula $w = l^3/56$ was calculated in which w = weight in grams, l = length in cm., and 56 = the constant. The heavy dashed curve was plotted from this equation. While it does not follow the smoothed curve perfectly it keeps well within the limitations required and the small discrepancies can be accounted for by the fact that the specimens weighed varied in sex, development of the gonads, and amount of material present in the alimentary tract.

SUMMARY.

1. *Spheroides maculatus* has a long spawning season, probably lasting all through the warmer months.

2. Artificial fertilization is readily accomplished and owing to the transparency, adhesive nature, and hardihood of the ova, as well as the vitality of the larvae, the species is ideally suited for studies of early development.

3. Incubation occupies about three days and ten hours at an average temperature of 67°F.

4. The critical period for the larvae of this species appears to be on or about the tenth day after hatching.

5. Preservation in formulin destroys the finer details but fails to make the eggs or larvae unidentifiable.

6. The food of *Spheroides* does not include organisms of any considerable commercial value.

7. The females average larger than the males.

8. In specimens of equal length the females are somewhat heavier than the males, at least in the breeding season, although this is irrespective of the condition of the gonads.

9. The relation of length to weight in this species is approximated by the formula $w = l^3/56$.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II. NUMBER 13

(Papers from the New York Aquarium)
(Contribution Number 6)

HERMAPHRODITISM OF A CROAKER, *MICROPOGON UNDULATUS* (LINNAEUS)

By C. M. Breder, Jr.

New York Aquarium

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

January, 1922

HERMAPHRODITISM OF A CROAKER,[1] *MICROPOGON UNDULATUS* (LINNAEUS)

By C. M. Breder, Jr.
New York Aquarium

During the months of July and August, 1920, a large number of croakers, *Micropogon undulatus* (Linnaeus), were taken in the pound nets operated at Young's Million Dollar Pier, Atlantic City, New Jersey. They appeared to be approaching the spawning season rapidly and some males were found from which milt would flow. No females were taken with ripe eggs however, so on August 9, when what appeared to be a female turgid with eggs was taken, considerable interest was aroused. Its proportions were as follows:

Total length	32	cm.
Standard length	27	cm.
Body depth	9.5	cm.

Externally it appeared to be normal in all respects and when it was found that stripping was not possible, curiosity prompted dissection. The explanation of its great body depth was apparent when it was seen that perfect sets of both ovaries and testes were present. The testes lay dorsal of the ovaries, but in all other respects the internal anatomy was of the usual character.

In the accompanying semi-diagramatic sketch of the ventral aspect of the dissected specimen all fatty tissue and mesentary membranes have been omitted. Only the digestive tract and sexual organs have been shown in detail. The stomach appears as a very small appendage, but that is the normal

[1] Published by permission of the United States Commissioner of Fisheries.

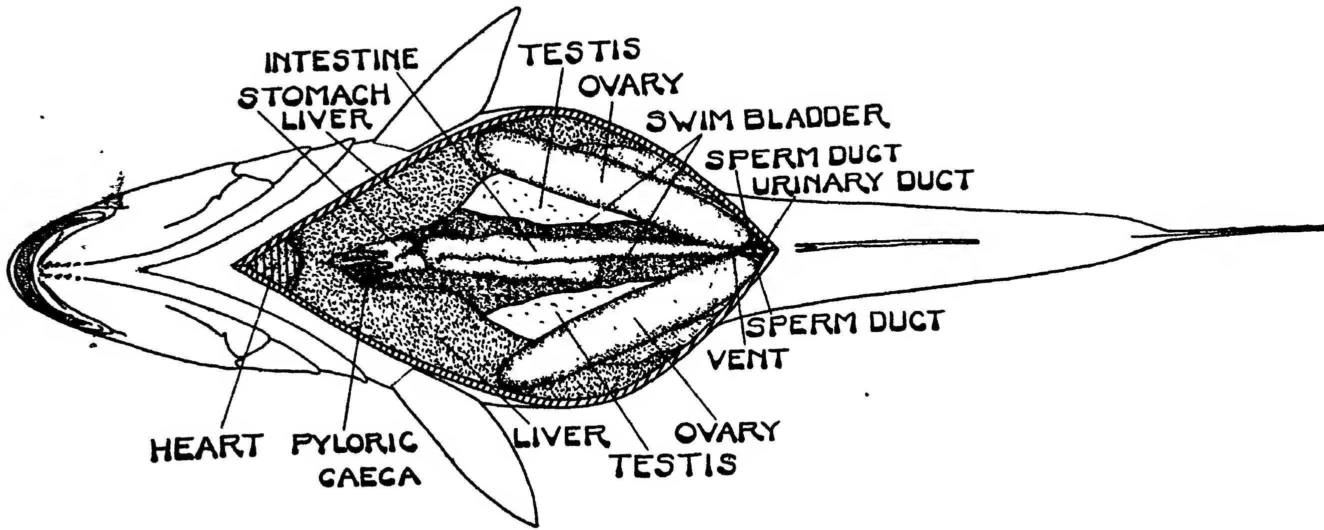

INTESTINE
STOMACH
LIVER
TESTIS
OVARY
SWIM BLADDER
SPERM DUCT
URINARY DUCT
SPERM DUCT
VENT
OVARY
TESTIS
LIVER
PYLORIC
CAECA
HEART

FIG. 97.

condition of the organ when the individual has not been feeding.

The only displacement of the viscera, other than that caused by the spreading due to opening the fish, is that of moving the anterior ends of the ovaries outward so as to show the testes lying dorsally of them. Before this separation, the ovaries were nearly parallel to each other and appressed against either side of the intestine. The paired fins indicated are the ventrals, the pectorals not being shown as the open flaps of body wall hide them completely.

The junction of the ova, sperm and urinary ducts appeared to be at the genital pore. This is shown in the diagram just posterior to the vent. The spermatic ducts can be seen passing around the rear end of the distended ovaries, which extend backward past the genital pore. The urinary duct passes between the posterior ends of the ovaries as it descends from the kidneys lying dorsally of the swim bladder, and is flexed forward to the external opening.

Both sets of gonads seemed well developed and in the state most frequently found in normal individuals of this species taken about the same time as this sportive example. The testes were soft and flocculent, and easily ruptured, the milt streaming out from such injuries, but they were not quite ripe enough to strip, and the ovaries were also a little too green for that operation.

Most previous records of hermaphroditism in fishes tell of one set being much in advance of the other in regard to development, but this specimen suggests speculation on the possibility of self-fertilization, which mechanically, at least, appears to be entirely possible. Scale examination and size indicate that this fish was about five years old and has therefore passed through at least one spawning season. The age of the fish together with the fact that the gonads were normal in themselves, strongly suggests that this is a case of functional hermaphroditism of which we have three possible methods of function: that is, self fertilization, and mating with other fish, either as

the male or female element or alternately, as first one and then the other.

To the best of the writer's knowledge bi-sexuality in teleosts has been recorded only from the following families and orders; *Cyprinidae, Clupeidae, Salmonidae, Esocidae, Poeciliidae, Gasterosteidae, Mugilidae, Percidae, Serranidae, Sparidae, Scombridae, Labridae, Squamipinnes, Gadidae* and *Pleuronectidae.*[2]

It is believed that no additions have been made to the above list up to the present time, so this notice stands as record of the addition of the *Sciaenidae* to it.

C. Stewart, in the Journal of the London Linnean Society (Zool.) 24 pp. 70-71, mentions the most nearly similar case, which is among the *Scombridae.* This is apparently the only other record in which the abnormality has approached symmetry; but even in the case of the mackerel the organs failed to reach the degree of symmetry found in the present specimen.

This example of abnormal hermaphroditism is now deposited in the U. S. National Museum, number 66140.

---

[2]This list, excepting the *Poeciliidae* and *Serranidae* was recorded by James E. Gemmill in his publication, "The Teratology of Fishes", 1912, James Maclehase & Sons, Glasgow, Pub. The occurrence of this type of monstrosity among the *Poeciliidae* was recorded by H. H. Newman, 1908 "A Significant case of Hermaphoditism in fish", Biol. Bull. Woods Hole, Mass., pp. 207-214. This reference however was listed in Gemmill's bibliography. The *Serranidae* are included in this list on D, S. Jordan's authority. In his "Guide to the Study of Fishes" 1905, p. 124, Holt & Co., N. Y., Pub., he states that *Serranus* is "sometimes truly hermaphroditic."

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME II. NUMBER 14

THE FOOD OF CERTAIN MINNOWS

A STUDY OF THE SEASONAL DIETARY CYCLE OF SIX CYPRINOIDS WITH ESPECIAL REFERENCE TO FISH CULTURE

BY C. M. BREDER, JR.
New York Aquarium

AND

D. R. CRAWFORD
United States Bureau of Fisheries

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, · NEW YORK

AUGUST 15, 1922

Volume II, Number 14

THE FOOD OF CERTAIN MINNOWS

A STUDY OF THE SEASONAL DIETARY CYCLE OF SIX CYPRINOIDS WITH ESPECIAL REFERENCE TO FISH CULTURE

BY C. M. BREDER, JR.
New York Aquarium
AND
D. R. CRAWFORD
United States Bureau of Fisheries

INTRODUCTION

The smaller members of the family Cyprinidæ although often neglected, are without doubt the most important of the small fishes which inhabit our fresh waters. To the practical fish culturist they are of greater importance than is usually recognized since they represent the food of many game and food fishes, while their diversity of species and habits, together with their interesting ecological relations, and availability, make them of considerable interest to the scientific student. A study of their intimate relationships and habits, therefore, is at once important from an economic and scientific standpoint. With these considerations in mind, this study of the food and feeding habits was essayed, since they are undoubtedly among the chief factors in the lives of these fishes.

FISH CULTURAL VALUE

The fact of primary importance to fish culture is that these minnows enter largely into the diets of the larger game fishes. At least twenty-three different predatory fishes are known to subsist largely upon various cyprinoids. They are as follows:

Lepidosteus osseus (Linnæus)..................Long-nosed Gar or Billfish
Hiodon alosoides (Rafinesque)................Golden-eye or Northern Moon-eye
Hiodon tergisus Le Sueur......................Golden-eye or Moon-eye
Pomolobus chrysochloris Rafinesque............Skipjack
Salmo sebago (Girard).......................Sebago Salmon

Cristovomer namaycush (Walbaum)	Lake Trout
Esox americanus (Gmelin)	Little or Bonded Pickerel
Esox reticulatus (Le Sueur)	Pickerel or Pike
Esox lucius Linnæus	Pike
Esox masquinongy Mitchill	Muskallunge
Aphredoderus sayanus (Gilliams)	Pirate Perch
Pomoxis annularis Rafinesque	Crappie or Croppie
Pomoxis sparoides (Lacépède)	Black Crappie or Calico Bass
Ambloplites rupestris (Rafinesque)	Rock Bass
Chaenobryttus gulosus (Cuvier and Valenciennes)	Warmouth
Micropterus dolomieu Lacépède	Small Mouthed Black Bass
Micropterus salmoides (Lacépède)	Large Mouthed Black Bass
Stizostedion vitreum (Mitchill)	Wall Eyed Pike
Stizostedion canadense (De Kay)	Gray Pike or Sauger
Perca flavescens (Mitchill)	Yellow Perch
Roccus chrysops (Rafinesque)	White Bass
Roccus lineatus (Bloch)	Striped Bass
Morone americana (Gmelin)	White Perch

After listing a number of species (included above), Forbes and Richardson ('08), add: "That th's list might be considerably enlarged by more extensive studies of the food of fishes is beyond a doubt, and it is safe to say that no fish-eating fish would, if hungry for fish, refuse a minnow of any kind unless it seemed too small to be worth the trouble capturing. . . . Moreover, by their great numbers, by their various adaptations and corresponding ecological d'stribution, and by their permanently small size, the minnows must distract in great measure the attention of carnivorous fishes from the young of the larger species, upon which, without them, the adults of these larger species would fall with the full force of their voracious appetites. . . . It is not too much to say, consequently, that the number of game fishes which any waters can maintain is largely conditioned upon its permanent stock of minnows."

Since the successful stocking of any stream with game fishes depends upon the food supply, it is essential to know how this important item may be maintained. As Forbes ('83) remarked, "Really intelligent fish-culture on any large scale, implies a full acquaintance with the food of the native species."

Fortunately, most of our streams east of the Rocky Mountains seem to be plentifully supplied with Cyprinoids, numerous species being found frequently in one stream. The availability of these fishes as a staple food for larger fishes depends upon their abundance, which, in turn, depends upon the abundance of their food. It is important, therefore, to know what these min-

nows eat at various seasons of the year. For this reason a considerable portion of this paper is devoted to the analysis of the stomach contents of specimens taken at various seasons.

Scientific Value

Ecologically and taxonomically the Cyprinidæ form a puzzling group. A study of the affinities of the various species is needed, both with reference to anatomical details and environmental conditions. In this connection, a knowledge of the food of the group throughout the seasons is of prime necessity and the results embodied in this paper, it is hoped, may be of value to other workers.

Minor Values

This group of fishes furnishes a large per cent of the bait to fishermen, sport for many a small boy, and a few of the larger species are used for human consumption.

Any or all of the different species of suitable size may be used as bait, many being hardy as live bait, but *Notropis cornutus* is probably the favorite among most of the fishermen. *Semotilus bullaris* is a wary fish and in some localities, at least, it is regarded as a minor sport fish.

Lastly, many of the species, in fact all of those which were collected in connection with this work, are attractive aquarium fishes, most of them becoming adapted to balanced aquaria, although they become adapted more readily to conditions in an aquarium supplied with running water.

Field Methods

In order to determine the nature of their food, collections were made of six of the common species of cyprinoids occuring in the District of Columbia.

A small stream known as Oxon Run was chosen for this purpose because of its accessibility and various physical features which will be subsequently described. It was decided that collections should be made once a month for one entire year. This plan was followed, except that no collection was made in August, but the collecting dates were so arranged that the greatest gap be-

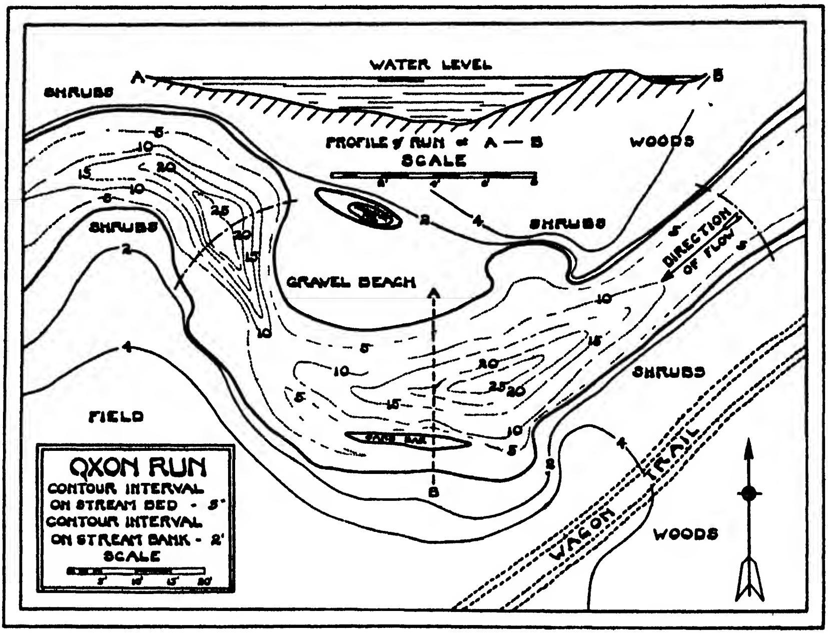


FIG 98 MAP OF COLLECTING SITE

The two curved lines crossing the stream mark the limits of the area in which the collections were made. This locality is indicated on the Washington Biological Society's Map (MacAtee '18) as S E G 12

tween any two was only 49 days, which period spanned that month.

Oxon Run is about 7.5 miles long and flows into the Potomac River near the southeast boundary of the District, opposite Alexandria, Va. In every way it is a typical steam such as found in the coastal plain region of Virginia and Maryland. It was observed that there was a considerable fluctuation in the amount of flow, depending on the amount of rainfall, and consequently, the turbidity varied accordingly. These changes were not detrimental to the work, although the swift current increased the difficulty of hauling the seine. The location shown on the map (Fig. 98) is about 2¼ miles above the mouth and was chosen because there is a rather deep eddy, on one side of which is a small beach providing an ideal place for hauling out the seine. The bank opposite this beach is rather high with overhanging shrubs, grasses and other plants. Upstream, the channel is nearly flat and has a gravelly

TABLE NO. I

PHYSIOGRAPHICAL CONDITIONS AT OXON RUN DURING 1920

Date	Temp. (Fahr.) Air	Water	Condition of Water Turbidity, Etc.	Depth	Weather Conditions
Jan. 1	48	37	Rather swift, fairly clear	12 inches	Partly cloudy
Feb. 1	29	32	2 inch ice over area seined	Greatest, 36 inches	Snow flurries. Cloudy
March 14	42.5	38	Slightly murky	Evidence of previous high water	Fair and windy
April 11	59	58			Fair
May 23	..	63			Partly cloudy; warm
June 13	89	71	Clear	Quite low	Partly cloudy
July 17	80	74	Very roily from children swimming		Sunny; hot
Sept. 4	83	66	Very clear	Low	Clear or partly cloudy
Oct. 4	75	57	Very clear	Very low	Fair
Nov. 7	61	48	Clear	Low	Cloudy
Dec. 5	65.5	49	Turbid, swift	Highest noted	

bottom that slopes gently, the water being about six inches deep at the low water stages. Down stream there are deeper places which were found unsuitable for seining. The table of physiographic conditions (Table No. I.) shows the general conditions and seasonal variations under which the collections were made.

All of our collections were made within the limits shown on the map by means of a ten-foot seine of one-quarter inch mesh. The bottom was quite free from snags and weeds of any kind and the only cover provided for the fishes was such debris as dead leaves and other materials which may have collected in the eddy. Even when the water was clear, few fishes were to be seen, yet the number of specimens collected gives some evidence as to their abundance. No definite number of hauls was made, since the catch each time was found to vary considerably, collecting

being continued until a sufficient number of specimens had been secured, or until the site had been exhausted temporarily of fish. The specimens were placed immediately into formal alcohol and sorted later in the laboratory. Formal alcohol was found to be an efficient killing fluid since it acted quickly thus preventing further digestion of the stomach contents and hardened the specimens without perceptible shrinkage.

Laboratory Methods

After the specimens were brought to the laboratory, the solution of formal alcohol was poured off and 75 per cent. alcohol substituted for permanent preservation. Each species was preserved in a separate bottle and the different monthly collections were also segregated. Each fish was measured, the standard length being recorded because this measurement was used in constructing curves of growth which are discussed further on. Since this is the only measurement referred to throughout the paper it is mentioned subsequently simply as length. Each specimen was provided with a paper tag numbered serially to provide a ready reference to each specimen. In all, there were 1554 specimens including six species.

The entire digestive tract of each specimen was removed and the contents pressed out on a glass slide. The material was examined with a low power of the compound microscope supplemented by higher powers when necessary. Pierce's method (Pierce '15)[1] was used to estimate the various quantities of food present It is apparent that such a method can yield only a rough estimate, but none other was found to be feasible on account of the time required to make more accurate volumetric determinations. It is pointed out that frequently only small quantities of food, such as the leg of a beetle or wing of a fly, would be found yet such material had to be listed as 100 per cent. coleopterous, or dipterous remains, as the case might be, since there was no evidence of other food having been eaten. However, these errors would be naturally compensating rather than cumulative and in the tables we present giving the averages of each collection, they lose significance.

[1] Briefly, in this method the contents of each example is considered as unity, the various items being expressed in terms of percentage by volume as estimated by inspection

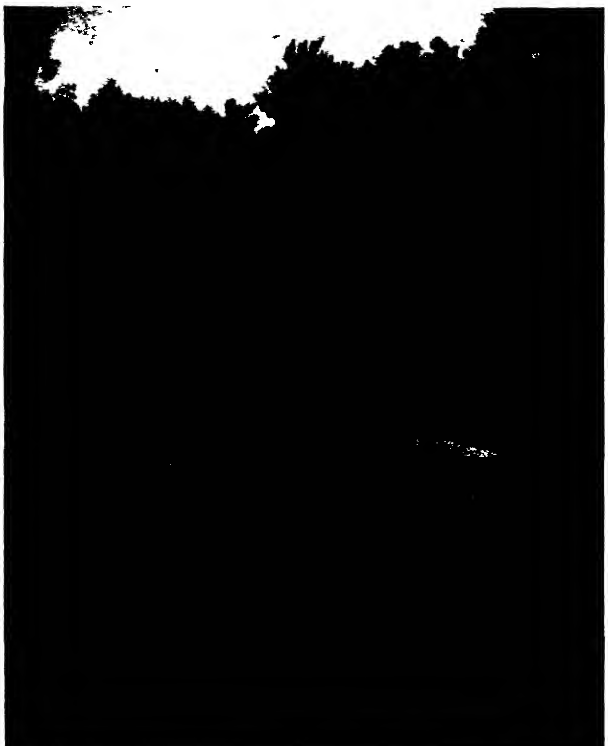


FIG. 99. VIEW LOOKING UP STREAM

FIG. 100. VIEW LOOKING DOWN STREAM

In taking these photos the camera was located a little beyond the upper and lower limits, respectively, of the area in which the collections were made. Taken in early October. See Map, page 290.

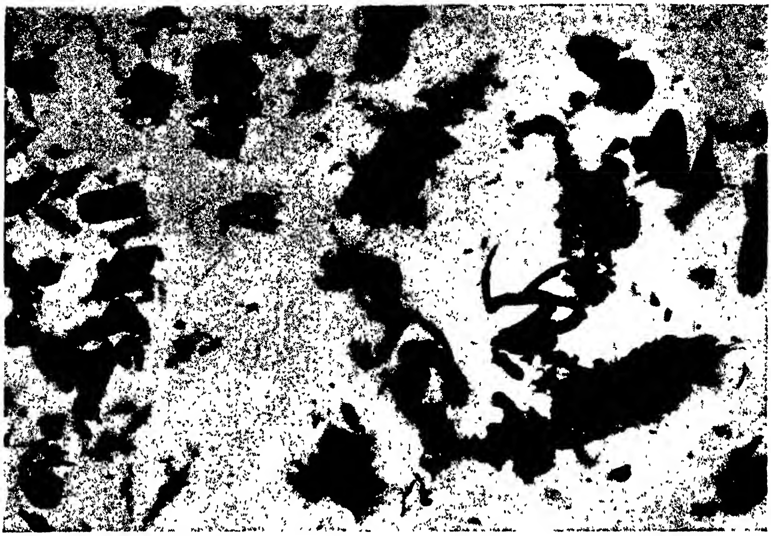


FIG. 101. ENTIRE CONTENTS OF THE STOMACH AND INTESTINE OF A SPECIMEN OF *NOTROPIS CORNUTUS* 7.3 CM. IN LENGTH TAKEN IN DECEMBER. 4X

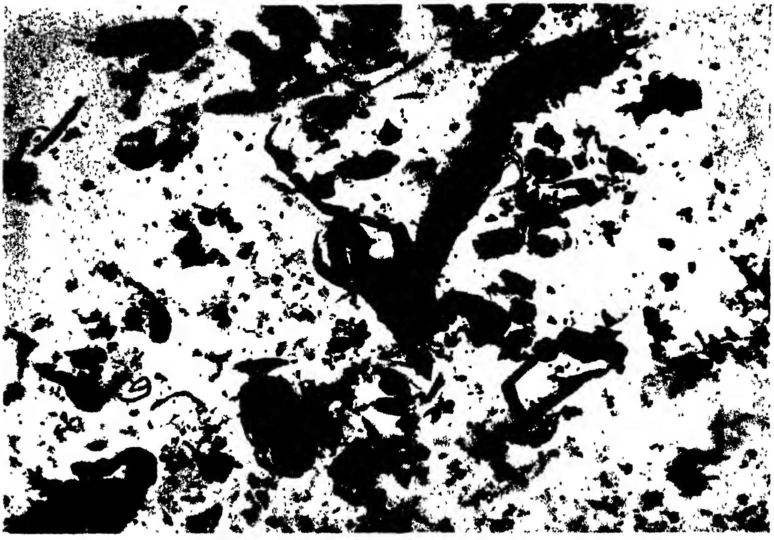


FIG. 102. ENTIRE CONTENTS OF THE STOMACH AND INTESTINE OF A SPECIMEN OF *NOTROPIS CORNUTUS* 5.7 CM IN LENGTH TAKEN IN DECEMBER. 4X

Photomicrographs showing the degree to which the food was usually found to be macerated.

The food was found to be masticated usually beyond the possibility of positive identification, as illustrated by figs. 101 and 102. This condition, doubtless, was caused by the action of the raptorial pharyngeal teeth possessed by these species. However, it was possible to distinguish insect remains from those of other organisms and often the various orders of insects such as Coleoptera, Diptera, etc., could be separated.

Our thanks are due Mr. J. T. Nichols, of the American Museum of Natural History at whose suggestion the problem was undertaken, to Dr. W. C. Kendall, of the U. S. Bureau of Fisheries, for determining the identity of certain specimens, and to Dr. R. E. Coker, for his kindness in allowing the use of the facilities of the Division of Inquiry of the latter institution. All illustrations have been made by the senior author.

Observations

Arrangement of Treatment by Species.—Complete statements and tables of the stomach contents of the six species on which this paper is based follow. A few general notes are followed by a discussion of the analysis of the data obtained. Following this, is the table of foods given in volumetric percentage by months. Opposite each date of collection is given the number of specimens which contained food and the number which were found to be empty. The modal, maximum and minimum lengths in millimeters are given next to convey a general idea of the size of the specimens examined. In cases in which no modal length is given the specimens were so scattered or few in number that no distinct mode was discernable from the frequency graph. Of course, in other cases the significance of the mode is directly proportional to the number of variants measured. In plotting these on graphic paper groupings of 4.0 mm. each were used throughout, beginning with 0 to 4 as the first group.

The body of the table in which the various organic substances are arranged in systematic order follows next, with the unidentified materials placed last. The figures for any one month indicate the averages for that collection. They have been reduced in practically all cases to whole numbers because figures closer than 0.5 per cent. have no particular significance, owing to the variation of the estimates and other uncontrollable factors. All such mate-

rials present in quantities of less than 0.5 per cent. are indicated simply by a plus sign indicating a mere trace. The general average for the whole year differs slightly from that which would be obtained by averaging the monthly numbers since the original calculations with all their fractional parts have been used because frequently the aggregate number of plus signs was sufficient to form a whole number. This grand average then also was smoothed in a similar manner to the method used for the monthly averages. Here, also, the value of the results is directly proportional to the number of specimens.

The table is followed in each case by a list of annotations amplifying and explaining certain features not expressed in the table itself or its preceding analysis.

Semotilus bullaris (Rafinesque) FALLFISH

Examples of *Semotilus bullaris* ranging from 1.6 to 12.2 cm. in length were taken. Those of the larger size were at once distinguished from *S. atromaculatus* of which a considerable number were taken also, by the black spot at the base of the anterior rays of the dorsal fin, from which the species takes its name. The very small specimens, however, were extremely difficult since most of the adult charactertistics had not yet appeared, and it was only after considerable study that they were separated to our satisfaction. *S. bullaris* is separated from *S. atromaculatus* chiefly by its larger scales and the crowded conditions of the anterior costal scales of the latter which is not apparent in very small specimens of *S. bullaris*. Most of the specimens taken were immature. None below 4.0 cm. were mature while most of those of greater length were sexually developed. Graphs were constructed plotting the lengths with their frequencies. Those below 4.0 cm., which formed the majority, composed a well-defined group forming a single mode as is indicated in Table No. II. No second mode was formed since the larger specimens were too few in number to show any tendency in that direction. The small number of mature individuals suggests that probably the adults run up the stream to spawn. This would be in accordance with observations of this species in various lakes where it is known that the adults spawn in the streams. Fowler ('08) records this

species as reaching a length of eighteen inches which is several times the length of our largest specimen.

Judging from the modal lengths of each collection these fish appeared to be chiefly of two-year classes; that is, most of those collected from January to July inclusive were undoubtedly of the spawning season of 1919. In September those of the 1920 spring began to appear in the collections, being by this time large enough to be unable to escape through the meshes of the seine. During the months of March, June, September, November, and December, a few larger individuals probably of greater age were taken.

Analysis of Stomach Contents:—Reference to the accompanying table plainly shows that this species is decidedly insectivorous, since these invertebrates formed 87 per cent. of the entire food of the 242 fish which were found to have been feeding. The plant remains amounting to only 5 per cent. apparently were taken incidentally. In September these remains were found to be present among the food in their greatest quantity (17 per cent.) but this relatively large amount in no way invalidates the conclusion that they were accidentally ingested, because none of the diatoms or algàe were found to be plasmolized which would have been the case if any of them had been acted upon by digestive fluids; or if they had been macerated, the alcohol would have completed that action. This, together with the fact that the unidentified debris also amounted to only 5 per cent., suggests that these fish are not bottom feeders, and as they do not have a superior mouth, (Figs. 103 and 111), the inference is that they captured most of their prey as it fell through the water at some point below the surface. It was observed that specimens in the aquarium usually fed in this manner. Assuming this to be the truth, the lack of diatoms and algae would be explained since in the locality where the collections were made these plants must have been taken from the bottom because of the absence of larger plants, brush, etc., to which such growths could adhere and flourish, while the swiftness of the current precludes the existence of pelagic forms. Some of what they took might well have been broken fragments drifting down stream from above which were snapped up in passing. Additional evidence that this species indulged in bottom feeding to only a slight extent is furnished by the fact that not a single grain of sand was found

Table No. II *Semotilus bullaris* Tabulation of Stomach Contents

DATE TAKEN	Jan. 1	Feb. 1	Mar. 14	Apr. 11	May 23	June 13	July 17	Sept. 4	Oct. 4	Nov. 7	Dec. 5	Totals
Number of Full Specimens	101	6	22	24	34	12	4	24	2	2	11	242
Number of Empty Specimens	13	12	23	3	0	0	1	0	0	0	4	56
Modal Length (mm)	30	22	30	32	34	38	...	26	...	...	...	Aver-
Maximum Length	44	36	88	52	48	52	56	44	48	122	72	ages
Minimum Length	16	16	24	20	24	36	44	20	36	28	28	
Diatoms	...	...	...	...	14	...	...	16	...	...	...	02
Filamentous Algæ	...	...	...	...	...	...	...	01	...	...	...	+
Unidentified Plant Remains	...	08	...	...	...	09	...	...	...	...	...	02
Total Vegetable Matter	...	*08*	...	...	*14*	*09*	...	*17*	...	...	...	*05*
Chætopoda	11	...	04	...	05	...	...	...	...	...	...	01
Decapoda	01	...	04	...	...	...	...	...	...	...	...	01
Diplopoda	...	...	...	04	...	...	...	...	...	...	...	01
Larval Ephemeroptera	08	....	...	...	...	...	...	...	...	...	...	01
Larval Plecoptera	11	...	04	...	...	...	...	...	...	...	14	02
Larval Coleoptera	01	...	...	...	...	...	...	...	...	...	...	+
Adult Coleoptera	06	17	39	24	45	33	50	16	100	...	...	30
Larval Lepidoptera	05	...	...	...	...	...	...	...	...	...	...	01
Crysilid of Lepidoptera	01	...	...	...	...	...	...	...	...	...	...	+
Larval Diptera	...	...	...	08	...	...	...	...	...	...	...	01
Adult Diptera	...	...	...	04	01	25	...	...	...	...	36	06
Adult Hymenoptera	...	...	...	10	12	...	...	16	...	...	...	03
Unidentified Insect	30	58	41	50	21	33	50	48	...	100	50	43
Total Insect Remains	*62*	*75*	*84*	*96*	*79*	*91*	*100*	*80*	*100*	*100*	*100*	*87*
Fish	...	...	04	...	...	...	...	...	...	...	...	+
Unidentified Debris	26	17	04	...	02	...	...	03	...	...	...	05

Jan. 1. The crustacean remains consisted of the chela of a *Cambarus* of small size. Among the debris was found a partly digested ctenoid scale, probably from a *Boleosoma*, the only abundant fish of this locality bearing such scales. All the Chætopods were small annelids. allies of *Tubifex*, etc. March 14 The crustacean remains consisted of the eye of a *Cambarus*. The fish had eaten a hydrophylid beetle, and a magot-like larva was among the unidentified insect remains. April. 11. Diplopods were represented by a fragment of a millepede. May 23. One individual had eaten a buffalo fly, two had taken ground beetles and four contained a white paste, together with the hard parts of beetles. The former was presumably the partly digested soft parts of these insects. Sept 4. An ant was present among the Hymenoptera.

in any stomach, although in several of the other species sand was found quite commonly.

No correlation of feeding habits and size was discerned in any case since all sizes fed on essentially the same types of organisms. The few exceptions noted are attributable simply to mechanical differences due to size. As an example, in March a *Boleosoma* was eaten by a fish 86.5 mm. in length. It is obvious that some of the smaller specimens could not have eaten a *Boleosoma* since many were smaller than the Darter itself. It may be noted here that not a single case of cannibalism was observed in any of the six species studied.

The tabulations of the number of fish found to be empty plainly shows that these fish feed considerably less during the cold months. On February 1, the coldest day on which a collection was made, when ice two inches thick was broken in order to operate the seine, twice as many of the stomachs were found to be empty as those which contained food and of the latter, two-thirds contained very little food.

This species appeared to be nearly free of intestinal parasites and no other kinds were noted among the entire series of 298 specimens. Only ten contained parasitic worms in the alimentary tract. These parasites were distributed as follows:—January, 4; February, 1; March, 4; April, 1. None was found in any succeeding months.

All foods other than insect were present in such small quantities that they cannot be considered important.

It should be noted here also that such bottom forms as the larval Plecoptera and Ephemeroptera were taken only in the colder months when fewer terrestrial insects were available, and the fish were naturally seeking deeper water on account of low temperature at the surface.

Incidentally fourteen specimens of *S. atromaculatus* were examined and it was found that they had partaken of food practically identical to that taken by *S. bullaris*.

Table No. III *Leusiscus vandoisulus* Tabulation of Stomach Contents

Date Taken	Jan. 1	Feb. 1	Mar. 14	Apr. 11	May 23	June 13	July 17	Sept. 4	Oct. 4	Nov. 7	Dec. 5	Totals
Number of Full Specimens	31	0	8	81	56	10	19	45	23	11	0	284
Number of Empty Specimens	3	0	0	1	1	0	2	0	3	0	0	10
Modal Length (mm)	58,30	...	...	48,30	52,34	34	42	42,30	34	38	...	Aver-
Maximum Length	64	...	54	64	60	52	56	56	56	56	...	ages
Minimum Length	20	...	30	20	20	24	32	20	28	32	...	
Diatoms	...	...	...	...	...	...	01	01	...	...	...	+
Filamentous Algæ	...	...	...	...	...	...	03	...	...	...	...	+
Total Vegetable Matter	...	...	...	...	...	...	*04*	*01*	...	...	...	+
Chætopoda	...	...	...	01	...	...	...	...	...	...	...	+
Decapoda	...	...	...	01	...	...	...	...	...	...	...	+
Adult Thysanura	01	...	...	...	...	...	...	...	...	...	...	+
Larval Ephemeroptera	28	...	24	...	...	...	...	...	...	...	...	06
Nymph of Odonata	...	...	...	...	...	...	...	01	...	...	...	+
Larval Plecoptera	16	...	...	...	...	...	...	...	...	...	...	02
Larval Trichoptera	...	...	...	...	02	...	...	...	...	...	...	+
Adult Orthoptera	...	...	...	...	01	...	...	...	...	...	...	+
Larval Coleoptera	02	...	08	...	...	...	...	...	...	...	...	02
Adult Coleoptera	13	...	...	38	77	...	21	27	08	...	...	20
Larval Lepidoptera	03	...	...	01	...	...	...	...	...	...	...	+
Adult Diptera	03	...	...	05	...	...	...	...	14	32	...	07
Adult Hymenoptera	...	...	19	02	02	30	05	04	04	04	...	08
Unidentified Insect	33	...	32	51	16	70	70	67	74	64	...	53
Total Insect Remains	*99*	...	*83*	*97*	*98*	*100*	*96*	*99*	*100*	*100*	...	*98*
Arachnida	...	...	05	01	...	...	...	...	...	...	...	+
Mollusca	01	...	...	...	...	...	...	...	...	...	...	+
Unidentified Debris	...	...	12	...	02	...	...	...	...	...	...	02

Jan. 1. A partly digested planarian was found among the debris. The molluscan remains consisted of a single specimen of *Limax*, sp. Among the remains of larval coleoptera was found a Parnid beetle. April 11. The decapod remains consisted of the chela of a crayfish. One specimen had eaten an ant. A single representative of each of the following families was found: Hydrophilidæ, Syrphidæ, and Chalcidæ. May 23. The following families of terrestrial beetles were found in many stomachs: Carabidæ, Elateridæ and Chrysomelidæ, the former two of which were represented by individuals small enough to be swallowed entire, but had suffered from subsequent maceration. Much of the unidentified insect was also very probably the remains of beetles. The Orthoptera was represented by a single small grasshopper. June 13. Most of the Hymenoptera were chalcid flies. July 17. Four maggots were found in one stomach. Sept. 4. Several kinds of insects were present among those entered as unidentified.

Leuciscus vandoisulus Cuvier and Valenciennes
ROSY-SIDED DACE

The specimens of *Leuciscus vandoisulus* that were collected for this study appeared to be of normal size. Fowler ('08) gives a length of from 1¾ to 3 3/16 inches which compares well with our maximum and minimum of 6.4 and 2.0 cm., (2.11 and 1.27 inches). This species has been recorded as having a maximum length of 5.0 inches. Our series which of course included very young fish, did not include any which reached Fowler's largest. There was no particular difficulty experienced in identifying the mature specimens because of the beautiful rose red streak on the sides brought out in the preservative both on the males and females. The young which did not have this distinctive mark were easily identified by their large gape of mouth and a certain dark pigment along one of the lateral fascia which showed through the skin and scales as a diagonal dark streak from shoulder to tail. (Breder, '20, b). This well served to separate this species from the other twenty-three taken at this locality. Ripe fish about to spawn were taken in May.

At least four of the collections show two distinct modes in the frequency graphs which clearly divides the fishes into two year-classes (Breder '20, a). The group of smaller specimens represents those which hatched in the spring or summer of 1919, while that of the larger fishes were mostly of the 1918 season, a few possibly being referable to 1917. In September, examples of fish hatched in the spring of 1920, entered the collections but so far overlapped those of 1919 as to merely shift the mode a trifle and lower the minimum lengths.

No correlation appeared to exist between size and feeding habits of this species, mechanical limitations alone entering.

Analysis of Stomach Contents:—The food of this species is practically identical with that of the preceding differing only in very minor details. In this species the insects amounted to 88 per cent. and the vegetable content to only a trace, reaching only 4 per cent. in the month of its greatest amount. In these fish the diatoms and algæ also were found in an unplasmolized condition, and the unidentified debris averaged only 2 per cent.

Table No. IV *Notropis procne* Tabulation of Stomach Contents

Date Taken	Jan. 1	Feb. 1	Mar. 14	Apr. 11	May 23	June 13	July 17	Sept. 4	Oct. 4	Nov. 7	Dec. 5	Totals
Number of Full Specimens	26	5	37	40	61	28	27	28	9	16	7	284
Number of Empty Specimens	7	7	33	6	1	0	0	0	0	1	0	55
Modal Length (mm)	38,18	22	38	38,22	38	42,26	42,34	42	42	46,38	42	Aver-
Maximum Length	52	48	52	48	52	52	48	44	44	48	48	ages
Minimum Length	16	16	28	20	32	24	32	32	28	32	40	
Diatoms	...	...	...	20	91	71	58	66	61	59	...	39
Filamentous algæ	...	...	...	...	01	...	26	33	01	01	...	06
Unidentified Plant Remains	...	20	...	...	...	...	...	...	...	...	...	02
Total Vegetable Matter	...	*20*	...	*20*	*92*	*71*	*84*	*99*	*62*	*60*	...	*47*
Unsegmented Worms	...	...	...	00½	01	01	...	..	...	...	...	+
Chætopoda	25	..	31	02	...	02	..	...	...	...	64	13
Larval Ephemeroptera	05	...	03	...	...	...	...	...	...	...	14	02
Nymph of Odonata	...	...	...	01	...	...	...	...	...	...	...	+
Larval Plecoptera	10	...	...	...	...	...	...	...	...	...	08	01
Larval Coleoptera	04	...	...	...	...	...	...	...	...	...	...	+
Adult Coleoptera	...	...	10	13	02	08	12	...	...	...	...	04
Larval Lepidoptera	11	...	...	...	...	...	...	...	...	...	...	01
Unidentified Insect	20	80	56	34	04	14	04	01	38	40	14	28
Total Insect Remains	*50*	*80*	*69*	*48*	*06*	*22*	*16*	*01*	*38*	*40*	*36*	*36*
Acarida	...	...	...	00½	...	...	...	...	...	...	...	+
Unidentified Debris	25	...	...	29	01	04	...	...	...	...	...	04

Jan. 1. Five fish contained parasitic worms. Feb. 1. Five specimens contained very little food, two had taken larval insects and one what appeared to be weed seed. March 14. Seven specimens held very little, one an insect larva and one was fairly full of food. The Chætopods were probably near allies of *Tubifex*. April 11. Five contained very little food, one a staphylinid beetle, while some of the worms eaten were very small. Two fish were the hosts of parasitic worms. The Acarida were represented by a few water mites in one stomach. May 23. Four specimens contained very little, one had an insect larva while two had two and three worms, respectively. Probably some of the algæ was *Voucheria*. One specimen contained sand and silt with what was probably vegetable debris. Many fish were very full. June 13. One had eaten very little. The debris was probably mostly of vegetable origin. July 17. Some of the algal remains were probably *Spirogyra*. Sept. 4. Eight specimens had ingested considerable sand. Most of the algæ was *Spirogyra*. Oct. 4. Two specimens contained sand grains.

The strongly oblique and capacious gape, (Figs. 104, 105, and 112,) suggests that this species is inclined to feed from the surface. This is well borne out by the table of foods, since in all probability the Thysanura were taken while being supported on the surface film. In aquaria it was noted that this cyprinoid tended to keep nearer to the surface than any of its associates.

In the specimen which had taken a larval caddis fly was found a small amount of detritus which was absent from the remaining specimens, 294 having been examined. This suggests that bottom feeding is only occasional. As in *Semotilus,* it is quite evident that the only regular bottom feeding was performed in the winter months with the exception of the above mentioned caddis fly and a dragon fly nymph taken in September. The low temperature and lack of food at the surface probably caused the descent of this species although some food could, no doubt, have been taken at times as it was released from melting blocks of ice as they drifted down stream.

Lighter feeding in winter is not indicated by the number of empty stomachs or their distribution in time, although if this species had been taken in February and December such a condition might have been suggested. Attention is called to the possibility of a semi-hibernation or dormancy, because no specimens were taken on the two collecting days which were most cold.

Notropis procne (Cope) Delaware Minnow

The examples of *Notropis procne* which were collected ranged in length from 1.6 to 5.2 cm. Fowler ('08) gives their lengths as reaching up to 2 11/16 inches which is a little in excess of what our maximum examples showed. It was easily distinguished from any of the other species which we took. However, we carefully scrutinized each specimen in order to exclude *N. bifernatus* which has not been recorded from this region, but has been taken in Maryland, just north of the District.

Five collections show what appears to be a double mode but the overlapping of the extremes is so great that it quite obscures any attempt to read the age of the various groups from such data alone. There is no differentiation of food with the advance in size.

Table No. V *Notropis cornutus* Tabulation of Stomach Contents

Date Taken	Jan. 1	Feb. 1	Mar. 14	Apr. 11	May 23	June 13	July 17	Sept. 4	Oct. 4	Nov. 7	Dec. 5	Totals
Number of Full Specimens	10	0	53	43	28	41	46	12	12	10	10	265
Number of Empty Specimens	1	0	20	5	0	0	0	0	0	0	0	26
Modal Length (mm)	54	...	54,30	26	38	54,34	38	42	42,30	58,30	...	Averages
Maximum Length	60	...	84	56	56	56	64	60	52	68	96	
Minimum Length	28	...	20	20	24	28	32	24	24	24	36	
Diatoms	...	...	...	...	94	05	15	77	33	29	...	25
Filamentous Algæ	...	...	...	...	...	...	27	08	+	38	...	07
Unidentified Plant Remains	...	...	...	...	...	03	06	...	...	...	04	01
Total Vegetable Matter	...	...	...	...	*94*	*08*	*48*	*85*	*33*	*67*	*01*	*33*
Unsegmented Worms	...	...	...	...	+	...	...	...	...	...	...	+
Chætopoda	08	...	01	01	...	...	...	...	...	...	04	02
Larval Ephemeroptera	42	...	06	...	...	...	...	...	...	...	21	07
Odonata Nympth	...	...	05	...	...	...	...	...	...	...	...	+
Larval Plecoptera	10	...	08	...	...	...	...	...	...	...	...	02
Larval Coleoptera	...	...	...	...	...	...	...	...	...	...	02	+
Adult Coleoptera	...	...	04	...	04	30	16	...	21	...	07	08
Larval Diptera	...	...	...	...	...	...	...	...	...	...	02	+
Adult Hymenoptera	...	...	04	...	...	03	02	...	04	...	...	01
Unidentified Insect	40	...	70	36	01	59	32	15	42	33	60	39
Total Insect Remains	*92*	...	*97*	*36*	*05*	*92*	*50*	*15*	*67*	*33*	*92*	*57*
Acarida	...	...	...	...	01	..	...	...	...	...	...	+
Unidentified Debris	...	...	02	63	...	...	02	...	...	...	...	08

Jan. 1. No correlation between size and food eaten could be found in this month's series, or in any of the others. Feb. 14. Very little had been eaten by fourteen specimens, three had taken gomphid nymphs, three had eaten ants, and one contained an unidentified insect larva. April 11. One had taken very little food. Most of the food was found in the posterior part of the intestine; which suggests that it had not been feeding recently, the time of collecting being 1:45 to 5:30 P. M. on a cloudy day. May 23. One specimen had taken very little. Three families of beetles were recognized: Staphylinidæ, Scarabaeidæ, and Chrysomelidæ. A single specimen of Rhynchophora was present. In several cases the chlorophyl from the plants ingested was visible through the thin body walls of small specimens. June 13. One specimen was extremely distended with food. Five contained parasitic worms; two some sand and mud, and one a single specimen of some species of Ichneumonidæ. July 17. One specimen had taken very little and two held three parasitic worms each. Some of the algæ was probably *Spirogyra*. Oct. 4. One held two parasitic worms and another some sand grains. Nov. 7. Three had taken very little food. Dec. 5. Four had eaten very little and one had four parasitic worms. The larval Coleoptera remains consisted of one parnid beetle.

Analysis of the Stomach Contents:—It may be seen at a glance that the feeding habits of this species are somewhat different from those of the two preceding forms. Here the vegetable remains exceed those of the insect, the respective percentages being 47 and 36. Also, the comparatively large amount of sand indicates a bottom feeding habit. In aquaria this was not observed to be especially noticeable, since most of the specimens kept well up in the middle water. The rather subterminal mouth does not suggest that these fish are bottom feeders to a much greater extent than *Semotilus*, although the food points strongly to that conclusion.

The number of empty stomachs and the months in which they were found indicates that this species also feeds less heavily in the winter than at other times.

Notropis cornutus (Mitchill) REDFIN

Our specimens of this species varied in length from 2.0 to 9.6 cm. According to Fowler ('08) this species appears to reach a length of about twice that of our largest. Many of our larger specimens were breeding fish. All above 4.0 cm. were mature while all those of less length were juvenile. In the frequency graph this point coincides with the gap or point of greatest depression between two modes when such were distinctly present. Collections in which only one mode was evident a few scattering specimens were always to be found on the other side of this line of demarcation. Obviously there were two year-classes represented here, and the group of smaller specimens was evidently from the spawning of the previous year, while the mature fish had passed through two or more winters. Here we have the same length of time required to reach maturity as was found necessary for *Leuciscus*. Ripe fish about to spawn were taken in May.

No correlation between size and the food taken could be found.

Analysis of Stomach Contents:—This species feeds upon about twice as much insect as vegetable matter. Judging from specimens in aquaria, they seem to be given to rather promiscuous feeding. As observed in captivity, they were noted to rise to the surface with both the force and grace of a trout although they seemed also to be quite adept at securing food from the bottom.

Table No. VI *Rhinichthys atronasus* Tabulation of Stomach Contents

Date Taken	Jan. 1	Feb. 1	Mar. 14	Apr. 11	May 23	June 13	July 17	Sept. 4	Oct. 4	Nov. 7	Dec. 5	Totals
Number of Full Specimens	31	1	7	25	18	4	24	16	21	37	7	191
Number of Empty Specimens	15	1	7	23	2	3	4	0	6	1	4	66
Modal Length (mm)	42, 22	...	.	42 22	...	...	38	38	38	26	42	Averages
Maximum Length	48	28	56	48	48	44	44	48	44	48	48	
Minimum Length	16	20	16	16	24	24	28	24	20	20	20	
Diatoms	...	...	...	...	55	...	01	90	57	40	...	22
Filamentous Algæ	...	...	...	...	01	...	01	...	01	17	...	02
Unidentified Plant Remains	...	...	...	...	...	..	01	..	...	...	...	+
Total Vegetable Matter	...	...	...	...	*56*	..	*03*	*90*	*58*	*57*	...	*24*
Chætopoda	10	.	...	...	...	...	...	...	...	22	04	04
Larval Ephemeroptera	03	...	...	...	...	...	...	...	...	...	...	+
Larval Plecoptera	11	...	28	...	...	...	...	...	...	...	14	05
Larval Trichoptera	...	...	...	16	...	...	...	...	...	...	14	02
Larval Coleoptera	...	...	...	..	...	...	...	...	...	...	10	01
Adult Coleoptera	02	...	...	04	22	...	...	09	04	...	...	04
Larval Lepidoptera	...	...	22	...	...	...	...	...	...	...	...	02
Adult Diptera	...	...	...	04	...	...	...	...	...	...	...	+
Adult Hymenoptera	01	...	...	...	...	...	...	...	...	...	...	+
Unidentified Insect	53	...	35	64	22	100	86	01	33	21	58	41
Total Insect Remains	*70*	..	*85*	*88*	*44*	*100*	*86*	*10*	*37*	*21*	*96*	*57*
Arachnida	01	...	...	...	...	...	...	...	...	...	...	+
Unidentified Debris	19	100	15	12	...	...	11	...	05	...	...	15

Jan. 1. Three contained unidentified insect larvæ and among the debris was a orm which evidently was not an annelid. March 14. Two specimens contained parasitic worms and one sand grains. April 1. Eight specimens contained very little; one an aquatic beetle; five contained parasitic worms; two unidentified insect larvæ. One fish was blind in the left eye. May 23. One contained very little; five contained parasitic worms; among the diatomaceous remains were noted a very few desmids. (Not listed in the table.) June 13. One contained very little food. July 17. Six contained very little food and two contained parasitic worms. Sept. 4. Six contained parasitic worms; one very little food; one sand grains. Oct. 4. One held parasitic worms and four unidentified insect larvæ, and three held sand grains. Nov. 7. Three contained sand grains. Dec. 5. One contained very little and one contained parasitic worms. Some of the unidentified insect remains was probably Coleoptera.

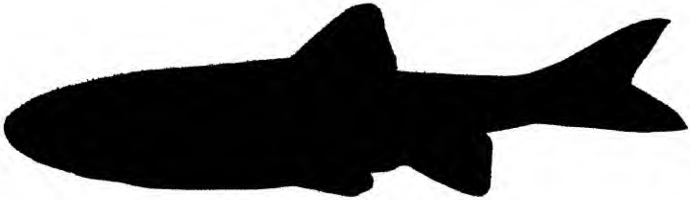


FIG. 103. *SEMOTILUS BULLARIS*
Standard length 12.0 cm.

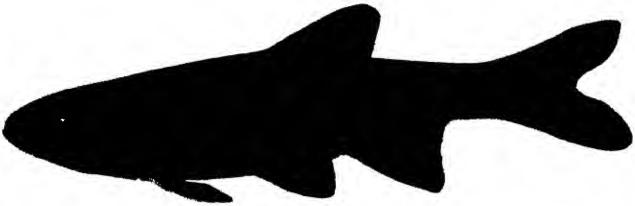


FIG. 104. *LEUCISCUS VANDOISULUS*
Standard length 6.3 cm.

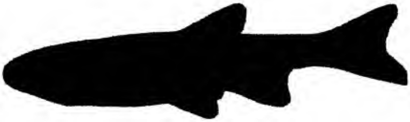


FIG. 105. *LEUCISCUS VANDOISULUS*, imm.
Standard length 3.8 cm.

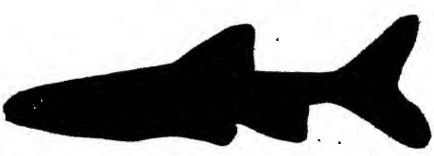


FIG. 106. *NOTROPIS PROCNE*
Standard length 4.6 cm.

FIGS. 103-106. FISHES FROM OXON RUN

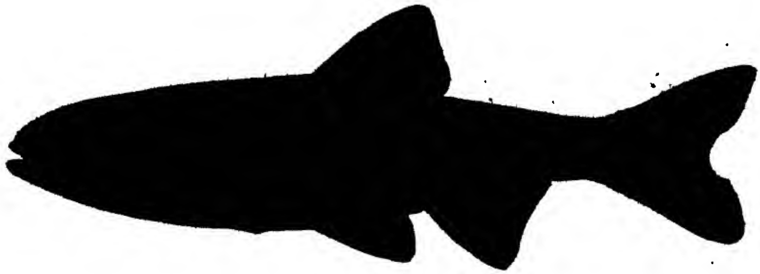


FIG. 107. *NOTROPIS CORNUTUS*
Standard length 9.0 cm.

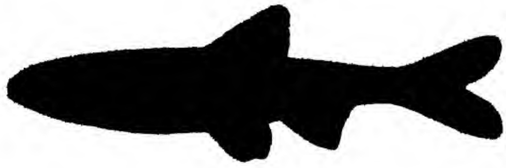


FIG. 108. *NOTROPIS CORNUTUS*, imm.
Standard length 5.3 cm.

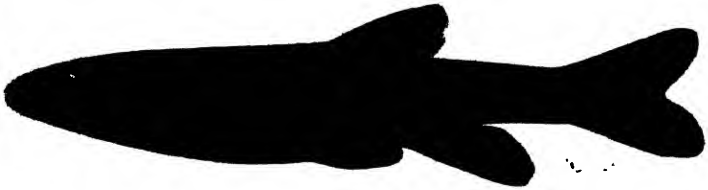


FIG. 109. *RHINICHTHYS ATRONASUS*
Standard length 3.9 cm.

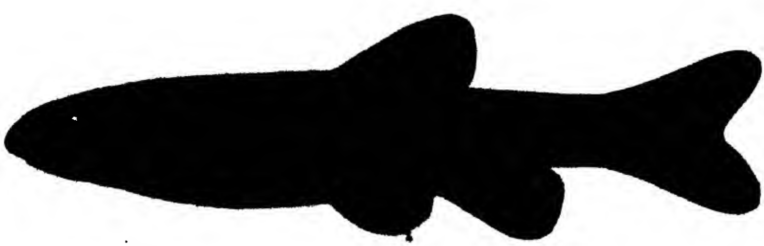


FIG. 110. *EXOGLOSSUM MAXILLINGUA*
Standard length 6.3 cm.

FIGS. 107-110. FISHES FROM OXON RUN

The percentage of empty stomachs and the months in which they occurred, in this case also, indicates a cessation of active metabolism during the cold season.

Rhinichthys atronasus (*Mitchill*) BLACK-NOSED DACE

This readily recognized species required close examination only to prevent the possibility of confusing it with *R. cateractæ,* which, however, was not taken in any of our collections. Our specimens varied in length from 1.6 to 5.6 cm. Fowler ('08) found his maximum to be 3½ inches, which is somewhat larger than ours. The smallest mature fish had a length of 3.0 cm. although a few above that size were immature. The two collections showing double modes on the frequency graphs presented the point of greatest depression between them at approximately the 3.0 cm. point. However, the overlapping of the year-classes was so great that very little information could be deduced therefrom. Nothing except the fact that more than one year-class was present could be satisfactorily determined.

Analysis of Stomach Contents:—This species appears to be intermediate in feeding habits between *Semotilus* and *Leuciscus* on one hand and the two species of *Notropis* on the other, the vegetable and insect remains appearing as 24 and 61 per cent. respectively. The unidentified debris amounted to a considerable quantity, constituting the remaining 15 per cent.

The numbe. of fish which were not feeding before the time of capture roughly suggests a lighter feeding in the colder months.

This species was the most heavily infested with intestinal parasites, although the fish seemed to show no ill effects from the presence of these worms since they were uniformly fat and healthy in appearance. In all, 22 examples out of the 257 specimens that were examined contained one or more parasites.

The vegetable remains were found to be almost exclusively in an unplasmolized state.

Specimens in the aquarium appeared to feed almost indifferently from either the bottom or middle of the tank, and occasionally rose to the surface.

Table No. VII — *Exoglossum maxillingua* — Table of Stomach Contents

Date Taken	Jan. 1	Feb. 1	Mar. 14	Apr. 11	May 23	June 13	July 17	Sept. 4	Oct. 4	Nov. 7	Dec. 5	Totals
Number of Full Specimens	0	0	2	3	9	20	9	4	1	9	. 2	59
Number of Empty Specimens	3	0	6	1	1	2	0	1	0	1	1	16
Modal Lengths (mm)	...	...	...	...	30	30	38	38	...	42	...	Aver-
Maximum Length	44	...	52	52	48	58	56	44	25	60	64	ages
Minimum Length	28	...	24	20	24	28	32	36	...	24	36	
Diatoms	...	...	...	...	26	05	11	37	...	...	...	08
Filamentous Algæ	...	...	...	...	+	...	...	...	...	...	...	+
Unidentified Plant Remains	...	...	...	...	...	...	55	...	...	...	...	07
Total Vegetable Matter	...	...	...	...	*26*	*05*	*66*	*37*	...	...	...	*15*
Chætopoda	...	...	50	...	22	57	...	13	...	23	100	30
Adult Coleoptera	...	...	...	...	08	...	...	...	...	...	...	01
Unidentified Insect	...	..	50	67	22	33	12	50	...	77	...	34
Total Insect Remains	...	...	*50*	*67*	*30*	*33*	*12*	*50*	...	*77*	...	*35*
Fish Ova	...	...	...	...	...	05	...	...	...	...	...	+
Unidentified Debris	...	...	...	33	22	+	22	...	100	...	...	20

March 14. Two specimens contained parasitic worms. The annelids were possibly *Tubifex*, or an allied species.

June 13. The fish eggs were represented by the ova of some small fish, probably a cyprinoid. In the same stomach were also several other ovate bodies, which were probably parasitic cysts. Two other stomachs contained parasitic worms. Some of the unidentified debris was probably of vegetable origin and some of the unidentified insect remains was probably Coleoptera.

July 17. One contained very little food. Some of the debris was probably of vegetable origin. In two stomachs there was sand in quantity equal to that of the food.

Sept. 4. Three contained sand.

Nov. 7. A larva was among the unidentified insect remains.

Dec. 5. One of the worms was a *Lumbricus*.

Judging from the relative frequency of Chætopods, Mayfly, and Stonefly larvæ, these fish feed more frequently from the bottom in the colder months, in a manner comparable to the behavior of the other species.

Exoglossum maxillingua (Le Sueur) CUT-LIPS

This unique and striking species presented no difficulty to identification in any way, the peculiar three-lobed mandible being entirely sufficient to at once isolate the species. The lengths of the specimens of our series varied from 2.0 to 6.4 cm. Fowler's ('08) maximum or 4⅞ inches (12.38 cm.) was about twice that of ours, although many of the latter were adult and in breeding condition. This cyprinoid has been recorded as reaching a length of 6.0 inches (15.24 cm.). The smallest mature fish was 4.3 cm. and the largest immature specimen was 5.8 cm. This excessive overlapping of the year-classes together with the unfortunate paucity of the collection precluded drawing of any conclusions as to age.

Analysis of Stomach Contents:—Something decidedly different in the food of this species might be expected judging from the peculiar formation of the lips, (Figs. 110 and 116). However, this was not found to be so, as practically all of the food of this species was similar to that taken by the others. The large amount of debris and vegetable matter suggests that these fish were primarily bottom feeders. In the aquarium, this was observed to be the case, the specimens for the most part poking around in little nooks and crannies among the rocks and negotiating with difficulty all but the smallest particles of food. However, they were seen to rise occasionally to the surface as small particles of food were descending through the water.

In this case, also, feeding was less heavy during the winter season. In those specimens which contained diatoms, the diatoms appeared partly digested.

DISCUSSION

Comparison of Foods:—Table No. VIII shows the foods of each species for the year side by side to facilitate comparisons.

Table No. VIII

Showing averages of foods taken by each species for entire collection
(Comparison by percentage)

FOOD	*Semotilus*	*Leuciscus*	*N. procne*	*N. cornutus*	*Rhinichthys*	*Exoglossum*
Diatoms	02	+	39	25	22	08
Filamentous algæ	+	+	06	07	02	+
Unidentified plant remains	02	—	02	01	+	07
Total vegetable matter	*05*	+	*47*	*33*	*24*	*15*
Unsegmented worms	—	—	+	+	—	—
Chætopoda	01	+	13	02	04	30
Decapoda	01	+	—	—	—	—
Diplopoda	01	—	—	—	—	—
Adult Thysanura	—	+	—	—	—	—
Larval Ephemeroptera	01	06	02	07	+	—
Odonata nymph	—	+	+	+	—	—
Larval Plecoptera	02	02	01	02	05	—
Larval Trichoptera	—	+	—	—	02	—
Adult Orthoptera	—	+	—	—	—	—
Larval Coleoptera	+	02	+	+	01	—
Adult Coleoptera	30	20	04	08	04	01
Larval Lepidoptera	01	+	01	—	02	—
Crysilid Lepidoptera	+	—	—	—	—	—
Larval Diptera	01	—	—	+	—	—
Adult Diptera	06	07	—	—	+	—
Adult Hymenoptera	03	08	—	01	+	—
Unidentified insect	43	53	28	39	43	34
Total insect	*87*	*98*	*36*	*57*	*57*	*35*
Acarida	—	—	+	+	—	—
Arachnida	—	+	—	—	+	—
Mollusca	—	+	—	—	—	—
Fish	+	—	—	—	—	—
Fish ova	—	—	—	—	—	+
Unidentified debris	05	02	04	08	15	20

The table clearly indicates that all of the species are rather insectivorous. Hymenoptera and Diptera were represented mostly by various minute chalcid flies and midges. Lepidoptera were represented by the larvæ of Geometridæ. All of the insects with few prominent exceptions were terrestrial species which evidently had fallen into the water.

Table No. IX shows in still more epitomized form to what degree each species was carnivorous. The species have been arranged in this table with the most carnivorous coming first. A superficial examination of this table no doubt would suggest to

Table No. IX

Showing degree to which each species is carnivorous
(Comparison by percentage)

SPECIES	Animal	Vegetable plus debris	Insect	Other animal	Vegetable	Debris
Leuciscus	98	02	98	trace	trace	02
Semotilus	90	10	87	03	05	05
Exoglossum	65	35	35	30	15	20
Rhinichthys	61	39	57	04	24	15
N. cornutus	59	41	57	02	33	08
N. procne	49	51	36	13	47	04

the reader that *N. procne* was decidedly vegetarian, the others somewhat so, but to a lesser degree, progressing upward toward *Leuciscus* which shows only 2 per cent. of vegetable matter and debris combined, for the whole year.

However, since most of the vegetable matter was found to have been undigested and all of these species have a short digestive tract and decidedly raptorial pharyngeal teeth, it seems unlikely that *N. Procne* or any of the other species are intentionally vegetarian. It must be noted, however, that in the case of *N. procne* the pharyngeal teeth present a greater grinding surface than in any of the other species, a few of the teeth being simply obliquely truncated cylinders. (Fig. 119).

The lack of vegetable matter in *Leuciscus* and *Semotilus* is easily explained by assuming that they feed above the bottom, as was pointed out in the individual treatments, pages 301 and 295 respectively. Also, the presence of considerable vegetation in the stomachs of *Exoglossum* and *Rhinichthys* may be explained by their known habit of nosing around near the bottom. All considerations point respectively to such habits of these four species: the food, the structure of the mouth, and the habits as observed in the aquarium.

However, in the case of *N. cornutus* and *N. procne* it is another matter. Tne trout-like grace of *N. cornutus* in no way suggested a typical bottom feeding fish, although a relatively large amount of plant and vegetable debris was found in this species.

Table No. X

Specimens containing no food by months
(Comparison by percentage)

SPECIES	January	February	March	April	May	June	July	September	October	November	December
Semotilus	11	66	51	11	00	00	20	00	00	00	25
Leuciscus	09	—	00	01	02	00	09	00	11	00	—
N. procne	22	58	47	13	02	00	00	00	00	06	00
N. cornutus	09	—	27	10	00	00	00	00	00	00	00
Rhinichthys	32	50	50	46	10	43	14	00	22	03	36
Exoglossum	100	—	75	25	10	09	00	05	00	10	33

In the case of *N. procne*, the only suggestions of bottom feeding were the very slightly inferior mouth and the rather prominent grinding surfaces of the pharyngeal teeth.

These considerations taken as a whole are not convincing that these fish are partly vegetarian. The impression left by this study was that most if not all of the vegetable matter was ingested accidentally along with the invertebrates which are usually associated with diatoms and filamentous algæ. The presence of these plants in such quantities can be explained by the fact that peristalsis in these fishes depends largely upon the mechanical action of forcing the food backwards as more food is eaten and consequently digestion is rather a slow process. Owing to this, the presence of the silicon and cellulose covered cells, of diatoms and algæ, for a more or less protracted period would be expected. Furthermore even the chitonous parts of insects can be discerned at times even in the excrement of these fishes.

In view of the fact that none of the vegetable matter seemed to have been acted upon by digestive juices, with the possible exception of diatoms in some specimens of *Exoglossum* previously noted (page 307), it seems to be an unwarranted conclusion from the examination of the stomachs of these fishes that they are vegetarian, or derive any perceptible amount of nourishment from vegetation ingested.

These fishes appear to be very adaptable to changing conditions of food and feeding. In an aquarium they take anything

and everything that is given to them, living or dead, both the food which might possibly have been taken in their native haunts and that which it would have been impossible for them to secure under ordinary conditions, i.e., unnatural foods, such as boiled egg, shredded wheat, cooked meat, boiled potatoes, et cetera.

It is easily demonstrated by means of simple experiments that these minnows will snap at any small particle alighting upon the surface of the water, or settling to the bottom. Whether or not the particle is ingested seems to depend upon its physical properties. To the fish it seemed to be immaterial whether one kind of food or another was presented provided it was of proper size.

"It seems likely to be a general rule," Forbes has written, ('80), "that a fish makes no more than a *mechanical* selection from the particles of food accessible to it, taking almost indifferently whatever edible things the water contains which its habitual range and its peculiar alimentary apparatus enables it to appropriate, and eating of these in about the ratio of their relative abundance and ease with which they can be appropriated at any time and place." The positive identification, therefore, of the different constituents of the food is of small importance when carried beyond a certain point.

The following tabulation seems to include all factors directly concerned with the act of taking food.

EXTRA ORAL

I. Habitat of food.

A. Geographical distribution.
The *ranges* of the food and feeder must overlap. This is necessary for "B" to be possible.

B. Exact, or local position.
The exact local habitats of the food and feeder must overlap and finally the individual feeder, and food unit must be in proximity.

II. Size and condition of food.

A. Limitations.

Upper. Too large to be swallowed and unsuitable for nibbling into small pieces.

Lower. Too small, or well concealed to be perceived by any of the sense organs.

INTRA ORAL

I. Tactile and taste reactions.

A. Tactile limitations.

Upper. Hard, sharp, rough, unmasticatable.

Lower. Soft, flocculent, "melting in mouth." Such food is not rejected intentionally, but most of it usually escapes through the operculum.

B. Taste seems to be unimportant since strongly medicated food only is rejected, and then not always.

Table No. X showing the percentages of empty stomachs for the various months, which by comparison with Table No. I demonstrates lighter feeding for all species during the three coldest months, January, February, and March. In February, only three of the species were represented in our collections which suggests hibernation or a secretive habit during the extreme cold weather. There appears to be no cessation of feeding in any case during the spawning season which in all species was indicated as extending from sometime in April to well into the summer.

Little can be said of the high percentage of empty stomachs in the series of *Rhinichthys* in June since it was composed of only seven specimens.

The general feeding habits of these six species appears to be remarkably similar even as much, or more so, than their anatomical structures. It is rather striking that so many members of the same family of fishes should become suitably adapted for survival in the same localities and still retain their specific identity, although in many cases the young were difficult to differentiate. It seems that all fill practically the same ecological niche and very likely we have here a case of intra-family convergence, rather than divergence from a recent common prototype.

Comparison of Alimentary Tracts

On the whole, there is no vast difference between the alimentary structures of the six species under consideration. However, the minor details vary considerably as shown by the dissections, (Figs. 111-116).

In making these dissections, the body wall of the left side was removed by cutting it through along a median line from the vent forward to a point just posterior to the cardiac cavity, from whence it was passed diagonally upward to a point dorsal of the pharingeals, thence following back just ventrally of the gonads to the vent. In this way, only the visceral cavity was laid open, the heart, gonads and air bladder and kidneys remaining hidden. Two perpendicular cuts were made; one above, and one below the oral cavity extending from the snout to the opened visceral cavity. Between these two cuts, all substance was removed down to the median plane, thus showing the mouth and pharynx in true cross section. In making the semi-diagramatic sketches all unnecessary detail was omitted for the sake of clarity. Thus the structures above and below the buccal cavity are indicated simply by conventional cross-hatching, as is likewise the pelvic girdle.

The intestine, in all cases a simple tube containing a single sigmoid flexure, was spread out somewhat. That is, the forward arm was drawn down and the posterior one upward. By simply swinging them up and down respectively to a nearly horizontal position and allowing their distal ends to act as fulcra, the normal location of the parts can be found. The forward arm would thus lie to the right and the posterior two to the left, one above the other. The liver with its two lobes drops curtain-like to either side of the intestine. Their derangement has been trivial, but slightly different in most of the sketches in order to show the parts to their best advantage.

The representation of all mesentary membranes and fat has been omitted in order that the details which the drawings were designed to show might not be obscured. Lettering of the parts also has been omitted since the shape and locations of the organs together with the descriptive text following is sufficient explanation.

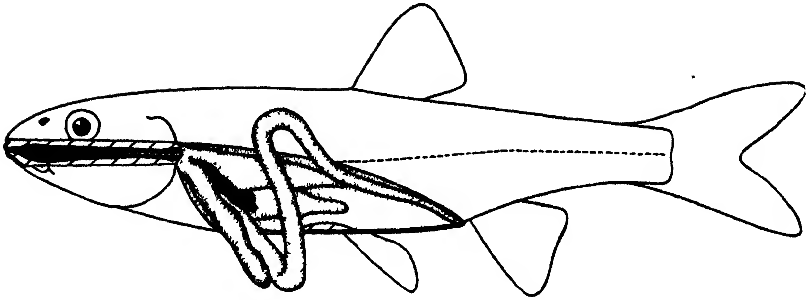


FIG. 111. *SEMOTILUS BULLARIS*
Standard length 12 0 cm.

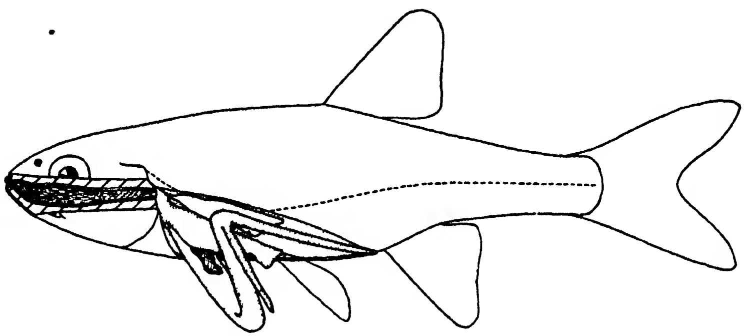


FIG 112. *LEUCISCUS VANDOISULUS*
Standard length 6 3 cm.

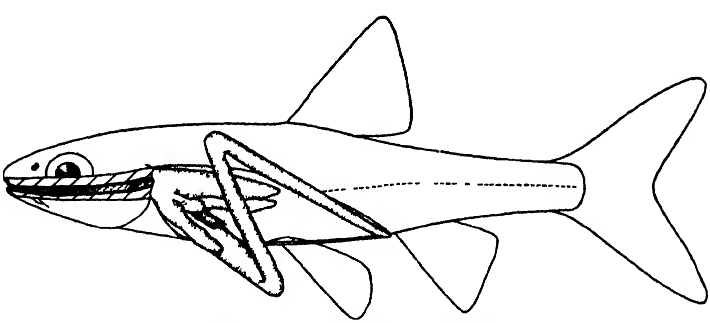


FIG. 113. *NOTROPIS PROCNE*
Standard length 4 6 cm.

FIG. 111-113. VISCERAL DISSECTIONS

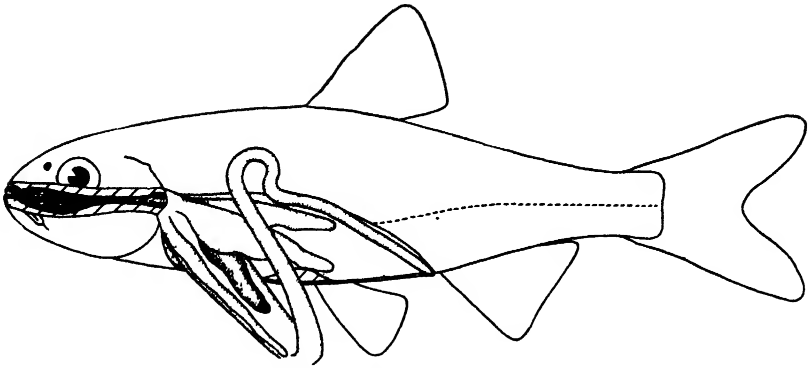


FIG. 114. *NOTROPIS CORNUTUS*
Standard length 9.0 cm.

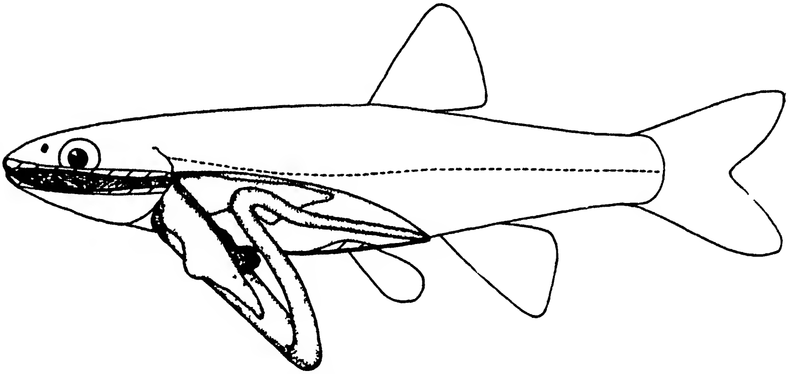


FIG. 115. *RHINICHTHYS ATRONASUS*
Standard length 3.9 cm.

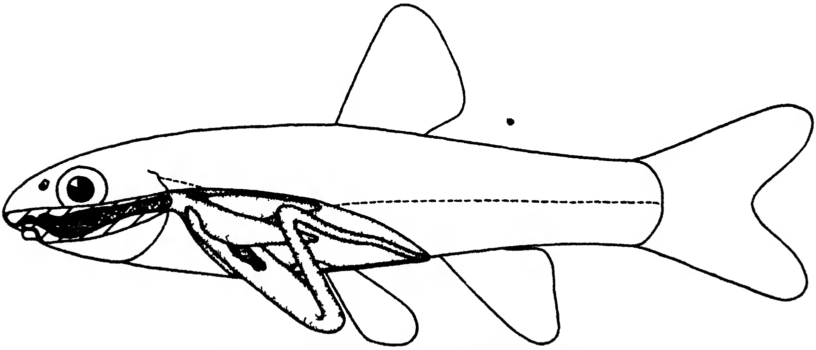


FIG. 116. *EXOGLOSSUM MAXILLINGUA*
Standard length 6.3 cm.

FIGS. 114-116. VISCERAL DISSECTIONS

For those readers who are not familiar with the internal anatomy of this group of fishes, it should be mentioned that the stomach is simply the widened anterior arm of the tube extending from gullet to vent, while the posterior portions are considered as intestine. The two-lobed liver (shown by light stippling) is attached to the anterior end of the stomach and the spleen, in all cases a small body (shown by dark stippling) is attached further back. The gall bladder is embedded in the liver and not shown. The pancreas in all cases (also shown in light stippling) lies ventrally to the stomach and it is bound to it with mesentary and is so embedded in fatty tissue that it is hard to differentiate. In all cases, except one, the point of attachment to the stomach wall was at its forward end. In *Leuciscus*, it was apparently attached at the first bend of the sigmoid flexure. However, this is a debateable point and in reality it may have been attached similarly to the others, although the drawing was made as shown only after many specimens were opened.

The structure of the mouth, its inclination and general conformation, are here, as in many other groups of animals, a very fair index to the food and feeding habits. The only species in which the mouth can be considered properly other than terminal are *Exoglossum, Rhinichthys* and *Notropis procne*. However, in the latter two, the mouths are very nearly terminal. The buccal cavity is much alike in all of them, being lined with an epithelium of the same general structure throughout. The most pronounced variation in this respect is in the odd formation of the mandible of *Exoglossum* which is so modified that it is divided into three lobes, the central one alone pressing firmly to the upper jaw. (Fig. 116).

There is some similarity in the pharyngeal teeth in all of the species. The comparative drawings show that the greatest difference in number of teeth between any two species is three. Most of the teeth are decidedly raptorial, with small grinding surfaces. The greatest variation is seen in *N. procne* in which some of the teeth are blunt and flat across the end with a fairly well developed grinding surface.

It should be noted here that the teeth were held in various positions to show the shape and number of teeth to the best

FIG. 117 *SEMOTILUS BULLARIS*
Standard length 5.5 cm

FIG. 118 *LEUCISCUS VANDIOSULUS*
Standard length 5.7 cm

FIG. 119 *NOTROPIS PROCNE*
Standard length 4.9 cm

FIG. 120 *NOTROPIS CORNUTUS*
Standard length 7.6 cm

FIG. 121 *RHINICHTHYS ATRONASUS*
Standard length 4.4 cm

FIG. 122 *EXOGLOSSUM MAXILLINGUA*
Standard length 3.9 cm

FIGS. 117-122. PHARYNGEAL TEETH
Diameter of black disc = 1 cm.

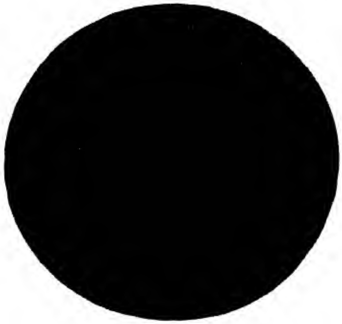


FIG. 123. *SEMOTILUS BULLARIS*
Standard length 4.2 cm.

FIG. 124. *LEUCISCUS VANDOISULUS*
Standard length 4.0 cm.

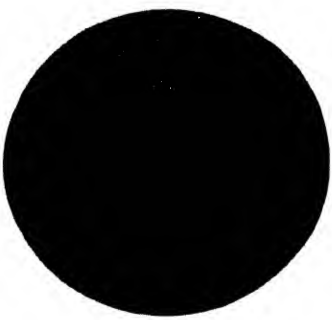


FIG. 125. *NOTROPIS PROCNE*
Standard length 3.9 cm.

FIG. 126. *NOTROPIS CORNUTUS*
Standard length 4.0 cm.

FIG. 127. RHINICHTHYS ATRONASUS
Standard length 4.0 cm.

FIG. 128. *EXOGLOSSUM MAXILLINGUA*
Standard length 4.0 cm.

FIGS. 123-128. INTESTINAL WALLS. 28X

advantage in each case.[3] This causes foreshortenings of the supporting pharyngeal bones in various ways, depending upon the angle from which they were viewed. In all cases the pharyngeal bones must bear the same relation to each other in order to accomplish their purpose of masticating the food, but their shapes depend upon the correlated differences of other related anatomical parts.

The stomach, or first arm of the digestive tract, is very similar in all cases, being a simple, nearly straight tube capable of considerable distention, and normally extending to a point slightly past the pelvic girdle. At its anterior end, the liver and pancreas are attached, except in *Leuciscus* in which the latter appears to be attached to the second flexure of the tube, as previously noted, although when the disarranged viscera are re-assembled it seems probable that this organ may be attached to either or both points since they are appressed closely in life. In this position, what appears to be the free end of the pancreas is brought in apposition to a possible point of attachment similar to that of the organ in the other species. In *Rhinichthys* and *Exoglossum* the pancreas appears to be reduced to a small, almost indistinguishable mass. The liver on the left side extends forward of the digestive tract in life and infolds it. The spleen is practically identical in all of the species, except for size and shape, both of which seem to be quite variable in individuals.

The differences in length of the alimentary tracts are too small to be used as an index of food habits. However, the two species of the single genus *Notropis* have the longest tracts. In the case of *N. cornutus* the tube has various curves and bends while that of *N. procne* is made up of three rectilinear sections. *Semotilus* and *Rhinichthys* follow in the order named and *Leuciscus* and *Exoglossum* possess the shortest digestive tracts. The lengths of all are characteristic of carnivorous fishes.

Heinrich Rathke ('24) recognized folds on the intestinal walls of certain European Cyprinoids similar in a general way to those of these species, illustrated by (Figs. 123-128). His list includes *Cyprinus gobio*, *C. jesus*, *C. aspius*, *C. vimba*, and *C. caras-*

[3] The accompanying wash drawings were modified from line drawings made through the camera lucida applied to a low power microscope. The teeth were removed carefully and cleansed, after which they were placed on a block of black parafin, which held them in any desired position and formed a contrastive background.

sius. Our figures of the intestinal walls of *Leuciscus, N. cornutus*, and *N. procne* appear to represent one type of folds which under low magnification give an effect somewhat similar to that of the herring-bone weave of cloth. These evidently are the "Zickzack falten" of Rathke. *Rhinichthys* and *Exoglossum* represent another type in which the folds anastomose to a great extent. These folds can be traced for a considerable distance along the top of the ridges without coming to a blind end. This is markedly different from the short, straight, or curved folds of the former three. *Semotilus* represents a still different formation. Here the ridges for the most part are short and heavy, and in many instances they are branched but are not anastomosing in any sense of the word. While these absorptive folds fall into three general groupings, each is distinctive and would serve as a character separating at least these six species.

Each of the figures[3] (123-128) represents a small piece of the intestinal wall taken from a point just posterior to the second angle in the modified sigmoid flexure of the intestinal tract. All of these sections were taken from as nearly similar places as possible and from specimens of about the same size in order to make as close comparisons as desirable.

Thus it is seen that the similarity of these six species extends to their alimentary structures and food. This fact, as previously pointed out, furnishes an illustration of the well-known principle that organisms living in the same environment and under similar conditions tend to develop similar habits and converge in details of their anatomical structures. It seems unlikely that this similarity is due to a divergence from a single ancestral type since these fishes are coexistant in the same locality and subject to the same conditions.

Fish Cultural Significance of These Cyprinoids

By study of the accompanying tables, listing the foods of the six species dealt with in this paper, the conclusion is drawn that these species, at least while they are young, will not destroy the

[3] The photographs are not all that could be desired, since it was found to be impracticable to thoroughly remove the mucus without destroying the ridges. However, the usefulness of the illustrations is not impaired. Alcoholic specimens were used. After the material had been cleansed as well as possible the pieces were immersed in glycerine to clear the tissue a trifle. The photomicrographs were taken with the aid of an Edinger projector, owned by the Bureau of Fisheries.

young of important food and game fishes. However, it is pointed out that insects and other small animals enter into the diet of all small fishes to a certain extent, and in so far as they do, therefore, these minnows must compete with all other fishes of a similar size and habitat. Nevertheless, it is difficult to overestimate the importance of these cyprinoids to fish culture. No doubt continued success in the cultivation of basses, crappies, and other species in ponds might be greater if suitable food could be provided for the growing fish and thus check their well-known cannibalistic tendencies. Similar difficulties in stocking streams with the various salmonoids might be overcome to a large extent by providing them with minnows for food.

All of these cyprinoids are not of equal value in practice and due regard for their variations in habit must be taken into consideration. For instance, if a stream is found to be suitable in every way for the introduction of trout, except that it is deficient in natural food, the deficiency might be overcome by introducing some of the smaller species of cyprinoids, such as *Exoglossum maxillingua*, or *Rhinichthys atronasus*, which are found in clear, rather swift streams. Other species are better adapted to a lacustrine habitat, such as *Semotilus bullaris*, or *S. atromaculatus*. In view of the fact that *S. bullaris* is predatory and sometimes reaches a length of thirteen inches and a weight of a pound or more, this species should be introduced with caution.

Since very little has been recorded concerning the rate of growth of these cyprinoids, success in propagating them in large quantities for fish food is problematical. It is known that some of the species will spawn in aquaria and that the young when reared with small tropical fishes will become adapted to the warm water conditions necessary for the latter. This suggests a method of procedure in stocking a pond with minnows, but the details of the experiment must be worked out for each species under local conditions.

There is no reasonable doubt that a pond may be stocked successfully with minnows provided that they are suitable. Brood stocks should be available in many places since these minnows are widely distributed and generally easily captured with a small seine. The suitability of a species selected for introduction will depend, of course, upon the similarity of its natural habitat to

Table No. XI

List of Species Taken at Oxon Run During 1920

Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Sept.	Oct.	Nov.	Dec.	Totals
1. *Lampetra wilderi*, J. & E. ..... (s)	0	1	0	0	0	0	1	0	0	0	1	3
2. *Catostomus commersonii* (Lac.) (s)	0	0	2	0	1	17	4	8	0	0	6	37
3. *Catostomus nigricans*, Le S. (m, s)	1	4	1	0	20	0	5	2	4	3	2	16
4. *Erimyzon sucetta oblongus* (Mitch.) (s)	1	1	0	0	2	0	2	0	0	0	1	5
5. *Hybognathus nuchalis*, Agassiz ..	0	0	0	0	0	0	0	0	0	2	0	2
6 *Pimephales notatus* (Raf.)	0	0	0	0	0	0	0	0	0	2	1	3
7. ***Semotilus bullaris*** **(Raf.)**.........	114	18	45	27	34	12	5	24	2	2	15	298
8. *Semotilus atromaculatus* (Mitch.)	1	1	6	1	0	0	2	0	1	1	0	13
9. ***Leuciscus vandoisulus, C. & V.***	33	0	8	82	57	10	21	45	26	11	0	294
10. *Abramis crysoleucas* (Mitch.)	2	0	0	0	0	0	0	0	0	0	0	2
11. ***Notropis procne*** **(Cope)**..........	33	12	70	46	62	28	27	28	9	17	7	339
12. *Notropis whipplii* (Girard) ... (s)	1	0	0	0	0	0	0	0	2	0	0	3
13. *Notropis analostanus* (Girard) ...	0	0	4	3	0	1	26	16	10	3	25	88
14. ***Notropis cornutus*** **(Mitch.)**.......	11	0	73	48	28	41	46	12	12	10	10	291
15. *Ericymba buccata*, Cope	0	0	0	0	0	0	0	1	1	0	0	2
16. ***Rhinichthvs atronasus*** **(Mitch.)**...	46	2	14	48	20	7	28	16	27	38	11	257
17. ***Exoglossum maxillingua*** **(Le Sueur)**	3	0	8	4	10	22	9	5	1	10	3	75
18. *Anguilla rostrata* (Le Sueur) (s)	0	1	0	0	0	0	0	0	0	0	1	2
19. *Fundulus diaphanus* (Le Sueur)..				Many specimens seen throughout the year								
20. *Lepomis auritus* (Linn.) ...... (s)	0	0	2	0	0	0	0	1	1	1	1	6
21. *Eupomotis gibbosus* (Linn) .. (s)	1	2	2	7	8	0	0	0	4	0	0	8
22. *Micropterus salmoides* (Lac.) (s)	0	0	0	0	0	0	2	0	0	0	0	2
23. *Boleosoma olmstedi* (Storer)				Very abundant throughout the year								

(s)—Small examples only. (m)—Medium sized examples. Certain species were counted and part returned to the stream, which accounts for the apparent discrepancy between the sum of the monthly numbers as shown, and the total, because the latter only includes preserved material.

that into which it will be introduced. Success may not be obtained by stocking ponds with species taken from swift, clear streams, unless, as suggested, the young are hatched and reared under pond conditions, or otherwise properly acclimatized.

It seems desirable to know,

(1) the spawning time, habits and place, in order that comparisons can be made between them and those of the species which will subsist on the minnows. It is obviously desirable to arrange conditions in such a way that the young fish under cultivation will find a supply of young minnows at the time when they are most needed; also

(2) how prolific each species of minnows is and length of time required to mature. However, certain factors, such as good protection to the eggs, etc., might compensate for small numbers; and

(3) the natural conditions under which the minnows live, so that these conditions may be reproduced as nearly as possible and thus assure a continuous supply.

No doubt, many natural ponds which have become over-run with chubs or other species of minnows because of their rapid growth, or because they are able to subsist better on the existing food supply to the exclusion of more desirable species, such as brook trout, could be made a valuable asset to the fish culturist if properly manipulated. The young of all of these cyprinoids are excellent and acceptable food for the young of all piscivorous fishes and if economical ways are developed for handling them, another natural resource may be developed. In all cases it is presupposed that all primary factors will be under the control of the fish culturist. If chubs are to be introduced into ponds when young, they should not be left to reach a large size and their introduction therefore, should depend upon the ease with which they may be removed, i.e., small ponds may be found more effective. Minnows seem to thrive best in streams or ponds where the banks are grown with overhanging vegetation which supports an abundance of insect life. If they are introduced into similar places where they will find their natural food in abundance it is unlikely that they will prey upon the eggs or young of other fishes.

NOTES ON ASSOCIATED ORGANISMS

In the course of making these collections, as shown by Table No. XI, seventeen other species of fish and fish-like vertebrates were accidentally seined. Two of these are new to the region, namely *Notropis whipplii* (Girard), (Crawford, '21), and *Lamptera wilderi* (Jordan and Evermann), (Breder and Crawford, '22). Up to the present, regional lists of the District of Columbia have shown twenty-three species of cyprinoids. With the addition of N. *whipplii,* the list is now twenty-four which shows that cyprinoids comprise over 25 per cent. of the fishes of this region. The three specimens which we took were small, being not over 5.4 cm. in length.

The only representative of the Petromyzonidæ hitherto known from the District is *Petromyzon marinus* Linnæus, the young of which *Lampetra* resembles. Considerable time and effort was consumed in establishing the status of our specimens which are now deposited in the American Museum of Natural History.

One of the specimens of *Erycimba buccata* presented the only decided abnormality taken in the entire collection, in that it was a fair example of the pugheaded condition which is quite common among other fishes. A few other minor abnormalities were noted, such as notches in the operculum and small irregularities in the fins. As a whole, however, the collection consisted of typically normal individuals.

The eels taken were both small, while two others were seen which we judged to be about 30.0 and 45.0 cm. in length respectively.

Previous to these collections, in September, 1919, several small specimens of *Schilbeodes insignia* were taken at this point and in February, 1921, a larger one was netted a short distance down stream. These records suggest that the number of species occasionally to be found at this collecting site may be considerably greater than our list shows, although collections were consistently made all through one year as well as scattering ones before, after and between the regular dates listed.

When all other organisms living associated with these fish, both vertebrate and invertebrate, are considered the aggregate

number is rather surprising. Small aquatic salamanders were found frequently, as well as frogs and their tadpoles. Land turtles visited the place at least occasionally. Kingfishers were seen frequently about and they no doubt preyed upon the fishes of this stream almost entirely. They were, no doubt, summer residents nesting in some sand or clay bank nearby of which there were plenty of suitable size and location. A drowned mole was noted and various bird and mammalian tracks furnished evidence of the presence of these warm-blooded creatures of sizes which varied from that of the song sparrow to man.

Among the invertebrates the crayfish and insects were the most prominent. A representative list of the latter is to be found among the list of foods in Table No. VIII. Many gomphid nymphs were present although but few of our cyprinoids were large enough to negotiate such formidable and sizeable insects. Practically no snails were present although a single specimen of *Physa* was taken from the stomach of a *Boleosoma.* Aquatic vegetation was entirely absent except for the very minute and ubiquitous representatives of algæ, none of which appeared to be particularly plentiful. The nearest approach to the larger aquatics was a very sparse growth of the semi-aquatic *Ludwegia,* which appeared to be gaining a foothold in the little cove just up stream of the beach on which the seine was hauled out. None was noted either above or below our collecting site. Fair growths of *Fontinalis* were noted beyond the limits of the map and seasonal fluctuations in the growth of this plant were observed.

SUMMARY.

1. The six species of cyprinoids treated in this paper are chiefly insectivorous.
2. Vegetable matter ranks second in volume of materials swallowed, but this material appears to have little or no nutritive value since the fish do not seem to be able to digest it.
3. The amount of food taken in the winter months is relatively small.
4. The seasonal abundance of the more prominent items of diet is reflected in the food of the six species.
5. No correlation exists between the size of the fish and the food taken except that which is entirely mechanical.

6. There is apparently no cessation of feeding during the breeding season.
7. A seasonal change from pelagic to benthotic feeding is shown more or less strongly by all species as the cold weather approaches.
8. The fish of this locality appear to be exceptionally free of parasites and abnormalities.
9. The alimentary structures are much alike in the various species.
10. These fishes are recorded as the food of many important food and game fishes.
11. It is believed that, if properly propagated, some of the species discussed in this paper would be of great value to fish culturists as food for other fishes.

BIBLIOGRAPHY

BEAN, B. A., AND WEED, A. C.

1911 Recent Additions to the Fish Fauna of the District of Columbia. Proc. Wash. Bio. Club. June 16, 1911. Vol. XXIV, pp. 171-174.

BREDER, C. M., JR.

1920 a. Some notes on *Leuciscus vandoisulus* Cuv. & Val. Copeia No. 82. May 20, 1920. New York. pp. 35-38. Fig. 1.

b. Further notes on *Leuciscus vandoisulus* Cuv. & Val. Ibid. No. 87. Oct. 15, 1920. pp. 87-90. Fig. 1.

BREDER, C. M., JR., AND CRAWFORD, D. R.

1922 *Lampetra wilderi* Jordan & Evermann in the District of Columbia. Copeia No. 103. Feb. 15, 1922. pp. 11-13.

CLEMENS, W. A.

1917 An Ecological Study of the Mayfly Chirontentes. University of Toronto Studies. Bio. Series, No. 17. pp. 1-43. 5 plates.

COKER, R. E.

1918 Principles and Problems of Fish Culture in Ponds. The Scientific Monthly. Vol. 7, No. 2. August, 1918. pp. 120-129. 2 plates.

CRAWFORD, D. R.

1921 A Record of *Notropis whipplii* from the District of Columbia. Copeia No. 101. December 20, 1921. New York. pp. 87-89. Fig. 1.

CONTRIBUTIONS TO CANADIAN BIOLOGY. FASC. II.

1915 Freshwater Fish and Lake Biology (various authors). Sessional Paper No. 396. Ottawa. pp. 222. 21 plates.

DAVENPORT, C. B.

1899 Statistical Methods. Special reference to Biological Variation. pp. 220. John Wiley & Sons, Publishers, London.

DYCHE, L. L.

1910-1914 Ponds, Pond Fish and Pond-fish Culture. State Department Fish and Game. Kansas. 3 parts.

FORBES, S. A.

1878 The Food of Illinois Fishes. Bull. Ill. State Lab. Nat. Hist. pp. 81-89.

1880 a. The Food of Fishes. Ibid. pp. 18-65.

b. On the Food of Young Fishes. Ibid. pp. 66-79.

1883 The Food of the Smaller Fresh Water Fishes. Ibid. pp. 65-94.

1888 a. Studies of the Food of Fresh Water Fishes. Ibid. Vol. II. Art. VII. pp. 433-473.

b. On the Food Relations of Fresh Water Fishes; a Summary and Dicussion. Ibid. Art. VIII. pp. 475-538.

FORBES, S. A., AND RICHARDSON, R. E.
1908 The Fishes of Illinois. Illinois State Lab.

FOWLER, H. W.
1908 A Synopsis of the Cyprinidæ of Pennsylvania. Proc. Acad. Nat. Sci. Philadelphia. December, 1908. pp. 517-553. Plate XXVII.

HAGEN, H. A.
1861 Synopsis of Neuroptera of North America. Smith. Misc. Coll. Vol. IV. Art. I. xx plus 347 pp.

HANKINSON, T. L.
1920 Occasional Papers of the Museum of Zoology. Univ. Mich., Ann Arbor. No. 89. July 15, 1920.

KENDALL, W. C.
1913 Fishes and Fishing in Sunapee Lake. B. of F. Doc. 783. pp. 21.

MARSHALL, W. S., AND GILBERT, N. C.
1905 Notes on the Food and Parasites of Some Fresh Water Fishes from Lakes at Madison, Wisconsin. Rept. U. S. Com. Fish. 1904. Appen., pp. 513-522.

McATEE, W. L.
1918 A Sketch of the Natural History of the District of Columbia. Bull. Bio. Soc. Wash. No. 1.

MOORE, EMMILINE, Ph.D.
1915 The Potomogetons in Relation to Pond Culture. Bull. U. S B. F. Vol. XXXIII. 1913. pp. 251-292.
1920 Some Plants of Importance in Pond-fish Culture. Appen. iv to Rep. U. S. Com. Fish, 1919. Doc. 881.

MORGAN, ANNA H.
1913 A Contribution to the Biology of Mayflies. Annals of the Entomological Society of America. Vol. 6, pp. 371-413. 13 plates. Columbus, Ohio.

NEEDHAM, JAMES G.
1905 The Mayflies and Midges. In Mayflies and Midges of New York. Third Report on Aquatic Insects. By J. G. Needham, Kenneth Morton and O. A. Johannsen. N. Y. State Mus. Bull. No. 86, pp. 17-36. Albany.

NEEDHAM JAMES G., AND BETTEN, C.
1901 Bull. 47, N. Y. State Mus. September. Univ. of State of New York.

NEEDHAM, JAMES S., AND LLOYD, J. T.
1916 The Life of Inland Waters. pp. 412. Comstock Co., Ithaca, N. Y., publishers.
1920 Burrowing Mayflies of Our Larger Lakes and Streams. Bull. U. S. B. F. Vol. XXXVI. 1917-1918.

PEARSE, A. S.
1915 On the Food of the Small Shore Fishes in the Waters Near Madison, Wisconsin. Bull. Wis. Nat. Hist. Soc. Vol. XIII. No. 1. pp. 7-22.

1918 The Food of the Shore Fishes of Certain Wisconsin Lakes. Bull. U. S. B. F. Vol. XXXV for 1915-16. pp. 245-292.

1919 Habits of the Black Crappie in inland lakes of Wisconsin. Report U. S. Commissioner Fisheries, 1918, Appendix III. (Suggestions on technical methods.)

PEARSE, A. S., AND ACHTENBERG, HENRIETTA

1920 Habits of the Yellow Perch in Wisconsin Lakes. Bull. U. S. B. F. Vol. XXXVI. 1917-18. (Research methods.)

RATHKE, HEINRICH

1824 Uber den Darmkanal und die Zeugungsorgane der Fische, in Schriften der Naturfarschenden Gesellschaft in Danzig.

REIGHARD, JACOB

1910 Methods of Studying the Habits of Fishes with an Account of the Breeding Habits of the Horned Dace. Bull. U. S. B. F. Vol. XXVIII. pp. 1112-1136.

1915 An Ecological Reconnaissance of the Fishes of Douglas Lake, Sheboygan County, Michigan, in Mid-summer. Bull. U. S. B. F. Vol. XXXIII. 1913. pp. 215-249.

SHELFORD, V. E.

1911 Ecological Succession III. A Reconnaissance of Its Causes in Ponds, With Particular Reference to Fish. Bio. Bull. Mar. Bio. Lab. No. 22, pp. 1-38. Also I and II.

1914 Suggestions as to Indices of the Suitability of Bodies of Water for Fishes. Trans. Amer. Fish Soc. Vol. XLIV. No. 1, pp. 27-32.

SMITH, H. M., AND BEAN, B. A.

1899 List of Fishes Known to Inhabit the Waters of the District of Columbia and Vicinity. Bull. U. S. B. F. 1898. pp. 179-187.

WARD, H. B., AND WHIPPLE, G. C.

1918 Fresh Water Biology. p. 1111. J. Whiley & Son, Publishers, London.

WELCH, PAUL

1912 Insect Life of Ponds and Stream. Part II. Nature Study Review. VIII. pp. 181-193.

WILSON, C. B.

1920 Dragonflies and Damselflies in Relation to Pond-fish Culture, With a List of Those Near Fairport, Iowa. Bull. U. S. B. F. Vol. XXXVI. 1917-18.

Besides the works listed, a number of lesser importance were consulted. They were omitted from the list because of their age and because they have been superceded by more general works or because they seemed less pertinent to the discussion of the food and feeding habits of the cyprinoids studied. References to other phases of such studies as the breeding and spawning habits, etc., may be found by consulting the various bibliographies appended to the different works cited in the foregoing list.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME II. NUMBER 15

THE FISHES OF SANDY HOOK BAY

By

C. M. Breder, Jr.

New York Aquarium

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

August 15, 1922

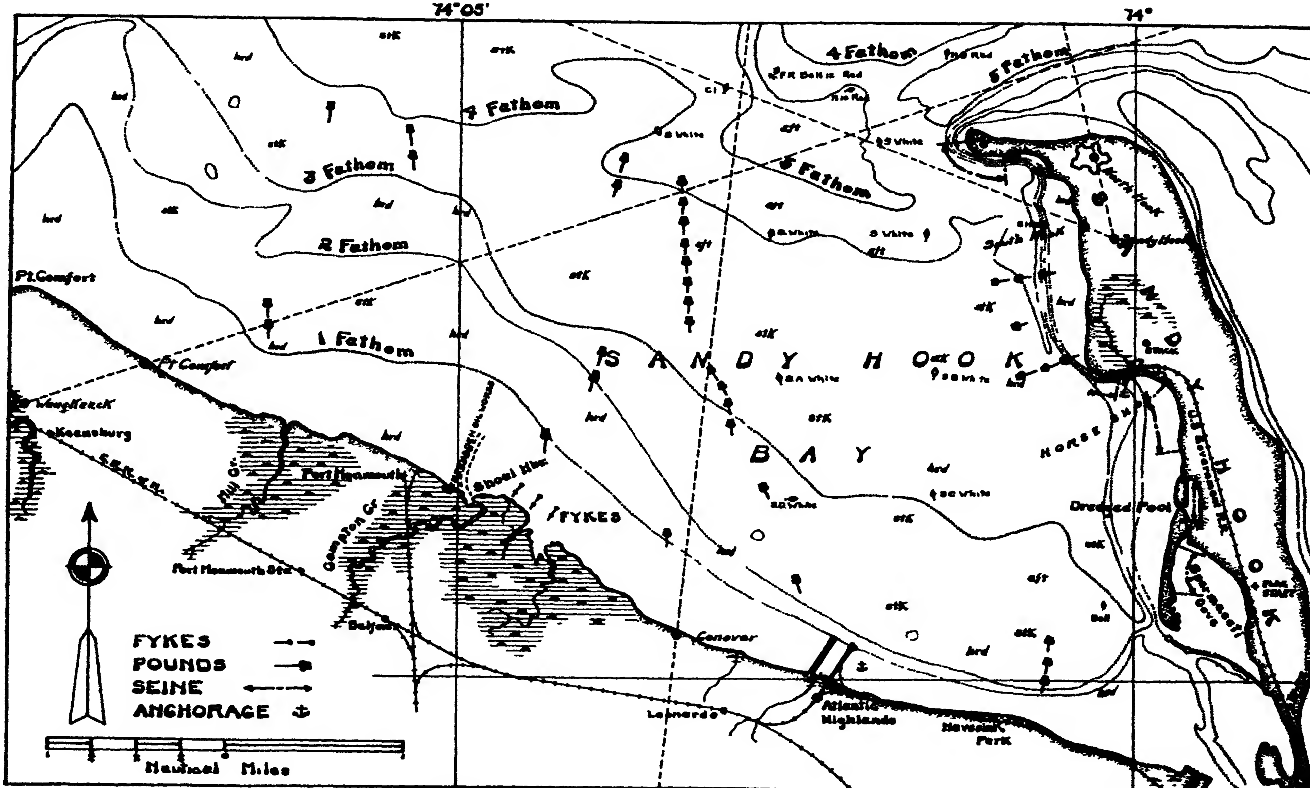


FIG. 129 MAP OF SANDY HOOK BAY

THE FISHES OF SANDY HOOK BAY

By C. M. Breder, Jr.

New York Aquarium

The work of collecting local marine fishes undertaken by the New York Aquarium's wellboat *Seahorse* for the exhibits of that institution has made it possible for the writer to compile an annotated list of the fishes of Sandy Hook Bay during the summer of 1921, which is herewith presented. Much of the material was gathered by visiting the various pound nets at times when the owners were removing their catches. There were thirty-five such traps within the limits of the Bay, and as the accompanying map shows, they were well scattered over the area, in this way intercepting at least a few individuals of practically all species entering the Bay which might be taken in such fishing gear. Late in the season when fykes were set they were likewise visited. They were six in number and located along the shore between Port Monmouth and Atlantic Highlands as indicated on the map. A seine, three hundred feet in length, was frequently used on the Beach of the Government Reservation at Sandy Hook, while less often smaller ones were dragged in tide pools and back waters. The shores along which the seines were operated are so marked on the map. Spermaceti Cove was seined only in 1920 as it was found to contain less material than numerous other places, which were more accessible. The beach at Atlantic Highlands was tried but once during 1921 when it was found to be rather unsatisfactory on account of the many submerged snags there present, upon which the net continually caught.

The first records of 1921 were made on June 1 and the last on October 21, which dates mark the beginning and end of the

boat's activity for the year. Between these dates records were made on fifteen trips varying in length from two to five days, the writer accompanying the boat on all except three. On these Mr. S. A. Callisen, of the New York Aquarium, was kind enough to record and report such notes as were of particular interest. Credit is also due him for giving various kinds of assistance in the compilation of this list.

Records relative to 1920 were made by Dr. C. H Townsend, Director of the Aquarium, who has permitted the use of his log book for that year. His notes extend from June 1 to November 8 and consist of data taken on twenty-four trips of from two to four days duration. As the trips were approximately equidistant throughout both seasons the collections and observations so made give a very fair idea of the fishes to be encountered during the summer in these waters. It is unfortunate that it was impossible to make trips before and after the dates mentioned as the seasonal aspect of the Bay for an entire year would be particularly valuable in regard to the study of the migrations of certain forms. However, it is doubtful if many species not mentioned in the list are present in any considerable numbers in winter.

The kindness of Mr. J. T. Nichols, of the American Museum of Natural History, in allowing a perusal of his scrap book of records and notes on local fishes leaves little doubt as to the authenticity of the early and late dates recorded in this list.

The most recent regional paper on the fishes of New Jersey is "A List of the Fishes of New Jersey" by Henry W. Fowler, Proceedings of the Biological Society of Washington, Vol. 33, pp. 139-170, Dec. 30, 1920. This publication gives, under specific captions, the region in which each species is found, by counties. It was rather surprising to find that seventeen species included in the present list have not been recorded,[1] according to Fowler, from Sandy Hook Bay or indeed from any of the waters of Mon-

[1] A short note on thirteen species found in 1920 has been published in Copeia, No. 91, Feb. 15, 1921, by C. H. Townsend and J. T. Nichols and a non-annotated list of sixty species taken the same year is given in "The Twenty-fifth Annual Report" of the New York Zoological Society, July, 1921. The substance of the former and all species included in the latter have been incorporated in this paper for convenience in reference.

mouth County.[2] When it is considered that Monmouth County has a long coast line on the open sea as well as on small bays, and that it is to the entire county that Fowler refers, the actual lack of accurate knowledge concerning the distribution of the fishes of this region is at once apparent. Notice to Fowler's omissions is given under the respective specific headings. Unfortunately the available regional lists of fishes found near New York City contain little or no information concerning exact geographical locations and are therefore practically impossible to compare.

Fowler, in addition, records about forty other marine species from Monmouth County, not in the present tabulation, but as no definite section is indicated, it is not known exactly how many have been taken in the Bay. This rather formidable looking list of names is made up, however, chiefly of pelagic and southern fishes of which comparatively few are likely to find their way into this body of water. While the writer's enumeration in no way pretends to be complete and is admittedly preliminary in nature, it is hoped that it will form an added step to a better knowledge of New Jersey fishes in which direction Mr. Fowler already has made such splendid advances.

The vernacular name following the technical one is, in each case, the local appellation known to be in actual use by the fishermen engaged in procuring their livelihood from this body of water, except in the cases of those few for which no local name appeared to be in current usage. In these instances the common names applied to the species in question in adjacent territories or proposed by other writers are given in brackets. All measurements given are standard lengths except where otherwise stated and in the case of the sharks where the total length is understood. The metric system is used throughout with the approximate English measure following. The annotation following each specific heading is separated into two parts according to the year in which the data was collected, so that the fauna of the Bay may be compared for two consecutive years and in this way be of aid to students of problems to whom such data might be of service. It is to

[2] Monmouth County has a coast line extending from a point a few miles south of the mouth of the Raritan River, on Raritan Bay to the mouth of the Manasquan River on the seaward coast.

be understood that the specimens were taken in pound nets if no other type of gear is mentioned.

GALEIDÆ

1—*Mustelus canis* (Mitchill) DOGFISH, DOGGIE

Common practically all season during 1920. In the warmest weather few were taken except in the pounds set in the deepest water near the point of Sandy Hook. During 1921 this species was few in number until October 10, after which time it was abundant, varying in length from about 40 to 102 cm. (16½ to 40 inches) and in weight from about .20 to 3.20 kilograms (½ to 7 pounds). A single specimen was taken in a seine near the point of the Hook. On June 1, several copepods were noted on some examples.

2—*Carcharhinus milberti* (Müller and Henle)
SHARK, SAND SHARK, GRAY SHARK

Some examples upward of 1 meter (about 3 feet), as well as smaller ones were taken in 1920 from July 15 to September 23. In 1921 one small example was taken on each of the following dates: July 8, 15, 27, September 19, and October 19. This last is a late date for the species, being over a month later than any previous record from this region. One specimen of larger size was taken in mid-July. Fowler gives a single record of this species, which he admits as being a questionable identification, from Monmouth County as being made at Perth Amboy, which locality actually is in Middlesex.

SPHYRNIDÆ

3—*Sphyrna zygæna* (Linnæus) HAMMERHEAD

Small examples, less than 60 cm. (about 2 feet), were seen during both years in mid-summer. Fairly common. None seen before July 14 or after August 26, during 1921.

CARCHARIIDÆ

4—*Carcharias taurus* Rafinesque SHARK, SAND SHARK

Thirty or more individuals seen between June 13 and October 4 in 1920, varying in length from about 60 to 214 cm. (2 to 7

feet). One about 121 cm. (4 feet) long was taken on July 28, 1921, and what was apparently another about 153 cm. (5 feet) was seen basking about five miles south of Coney Island on September 29, which position, however, is really outside the confines of the Bay.

SQUALIDÆ

5—*Squalus acanthias* Linnæus SPINED DOG, THORNED DOGFISH

Taken late in fall of 1920 up to November 8. Many small ones, mostly under 30 cm. (about 1 foot) taken between October 17 and 21, 1921.

RAJIDÆ

6—*Raja erinacea* Mitchill SKATE

Taken on June 1 of both years, and on October 13 and later in 1920. A single example was taken on October 10, 1921. Apparently absent from these waters during the summer months.

7—*Raja eglanteria* Bosc SKATE

Fairly common during season of 1920 except in September. During 1921 quite common from June 1 to July 29, and from October 10 to 21. This species, while generally more common than the preceding, tends likewise to absent itself from this locality in the warmest weather. October 21 is a late date for this Skate.

8—*Raja stabuliformis* Garman BARNDOOR SKATE

Taken in November, 1920. One example about three feet in length of disc taken in October, 1921.

DASYATIDÆ

9—*Dasyatis centrura* (Mitchill) STINGER, STINGAREE

Two were taken between June 20 and September 23, 1920. In 1921 a single example was taken on September 16 and another on September 20, both with a length of disc less than 45 cm. (about 18 inches).

MYLIOBATIDÆ

10—*Rhinoptera bonasus* (Mitchill) STINGER, STINGEREE

A few taken between June 13 and September 11, 1920. One example with a disc of more than 60 cm. (about 2 feet) in length, taken on August 4, 1921.

ACIPENSERIDÆ

11—*Acipenser sturio* Linnæus STURGEON

Fairly common in fall of 1920. One example 45 cm. (about 18 inches) long was taken on September 15, 1921. Fishermen reported having taken a few others about this time.

12—*Acipenser brevirostrum* Le Sueur STURGEON

A few small examples were taken in the fall of 1920. Fowler makes no mention of this species being taken in Monmouth County.

ELOPIDÆ

13—*Elops saurus* Linnæus SALMON

One example 20 cm. (about 8 inches) long was taken on October 12, 1921. Fishermen spoke early in the season of taking "Salmon" but the identity of the fish they had in mind could not be determined from their descriptions. Very likely they referred to this species. Cape May is the only New Jersey county Fowler records it from.

CLUPEIDÆ

14—*Etrumeus teres* (De Kay) [ROUND HERRING]

One example of 37 cm. (about 15 inches) was taken in a fyke on September 20, 1921. The fishermen admitted to not having seen this species before and had no name for it. According to Fowler it has not been recorded from Monmouth County before.

15—*Clupea harengus* Linnæus HERRING

A few medium sized examples were taken from June 1 to 23, and one each on July 7 and October 17, 1921. This species is known to be irregular near here, but these observations might be taken to indicate that possibly the Herring is absent from this

Bay in summer. Fowler does not record it as being found in the waters of this county.

16—*Pomolobus pseudoharengus* (Wilson) ALEWIFE, SHADINE

One example of medium size taken on June 1, 1921. Probably a few of this and the following two species were present later, but as it was not always possible to examine each catch in the detail necessary to identify such inconspicuous fish in a boat load of Menhaden it can not be said with certainty.

17—*Pomolobus æstivalis* (Mitchill) SHADINE

From June 1 to July 7, 1921, a few medium sized examples were taken.

18—*Alosa sapidissima* (Wilson) SHAD

Several were taken in 1920 and a few on June 1, 1921.

19—*Opisthonema oglinum* (Le Sueur)
THREAD HERRING, SAW-BELLY

A few were taken in mid-summer in 1920. Medium sized examples were taken from July 7 to 29 and one on October 21, 1921. Very likely they were absent in the interim. Fowler records this species only from Cape May and Atlantic Counties.

20—*Brevoortia tyrannus* (Latrobe)
BUNKER, BANKER, MOSSBUNKER, MENHADEN

Taken at all times during both seasons. Both young and adults abundant, and taken in all gear. As the season of 1921 came to a close their numbers became noticeably less, especially after the middle of September, at which time the Weakfish replaced them to a certain extent. This species forms by far the major part of the pound netters' catch, sometimes to the exclusion of almost everything else. On July 28 a skiff was taken up the "Creek" that has its mouth at the "Horseshoe" on Sandy Hook, and many young Menhaden 10 to 13 cm. (about 4 to 5 inches) long, were seen as far up as it was possible to force the skiff, which was almost a mile, measuring along the bank. This "Creek" is apparently purely salt water, at present, at least, being

merely an arm of the Bay. On July 27 and 28 countless numbers of these fish of a similar size were seen in great schools from the pier at Atlantic Highlands. At this point a large sewer empties just below the surface and the water is consequently heavily charged with various kinds of evil smelling debris. These young fish were in the thick of it, stemming the rather forceful current which the flow from the sewer pipe caused. It appeared that they were feeding, either on the finely divided sewage itself, or else on some small organism drawn there by the large amount of decaying organic matter, although it hardly seems possible that a small pelagic invertebrate, minute enough for these fish to engulf could sustain itself in the strong current urging the debris from the pipe.

About the middle of September several decidedly greenish adults were seen which the fishermen say always appear at this season and which they dub "Irish Bunkers." From a casual examination it was seen that they had fed on some green substance and that the internal organs were likewise suffused with the same color.

ENGRAULIDIDÆ

21—*Stolephorus brownii* (Gmelin) [STRIPED ANCHOVY]

One example was taken on June 7, 1921, in company with the following species. Not previously recorded from Monmouth County according to Fowler.

22—*Stolephorus mitchilli* (Cuvier and Valenciennes) [COMMON ANCHOVY]

Taken in small numbers on June 7, 29, September 22, October 18 and 21, 1921. Probably present all summer but passing through the meshes of most gear. Large schools of anchovy-like fishes were seen which were very likely composed of this species with a few individuals of the preceding, in proportion to their relative abundance.

ANGUILLIDÆ

23—*Anguilla rostrata* (Le Sueur) EEL

Taken uniformly on practically all trips and in all gear. Both large and small examples were seen.

PŒCILIIDÆ

24—*Fundulus majalis* (Walbaum) KILLY

Taken whenever fished for with small seines in back waters, tide pools, and runs. Especially common in the "Horseshoe." Ripe males and females taken June 1 to 23, 1921. In company with the following species but not as abundant.

25—*Fundulus heteroclitus macrolepidotus* (Walbaum) KILLY

Abundant, especially in back waters and tide pools, particularly so in "Dredged Pool." Taken whenever such places were seined. Ripe examples of both sexes were taken June 1 to 23, 1921.

26—*Cyprinodon variegatus* Lacépède KILLY

Taken only in the large and deep "Dredged Pool" in company with the two preceding species. Males with brilliant coloring seen from June 1 to 23, 1921. Apparently breeding at this time as were the other Pœciliidæ. Specimens apparently spent were taken on July 14 and 22, 1921.

BELONIDÆ

27—*Tylosurus marinus* (Walbaum) BILLFISH

Taken in the late fall of 1920. One example 45 cm. (about 18 inches) long was taken in seine on September 27, 1921 and another in a pound net on October 14, the latter being 60 cm. (about 2 feet) long.

GASTEROSTEIDÆ

28—*Apeltes quadracus* (Mitchill) STICKLEBACK

One small ripe female taken in back water of the "Horseshoe" on June 1, 1921, and a few, of which the condition was not noted, on July 20 in "Dredged Pool." Fowler gives this species as being unrecorded from Monmouth County.

SYNGNATHIDÆ

29—*Syngnathus fuscus* Storer PIPEFISH

Taken in mid-summer of 1920, especially abundant in Spermaceti Cove. Taken between June 23 and October 12, 1921.

Common near the point of Sandy Hook and in the "Horseshoe" in seines. Many males with brood pouches full were observed in mid-summer of this year. At times while riding at anchor in calm weather these fish could be seen swimming or drifting past, a few inches below the surface of the water. On June 21 a post larval example of 13 mm. (about ½ inch) was taken in a bolting cloth tow net at the surface near the mouth of the bay.

30—*Hippocampus hudsonius* De Kay SEAHORSE, HORSEFISH

One specimen taken during 1920. On August 24 and 26, 1921 each, one fair sized example was picked off the leaders of the pound nets by the fishermen. Several others were reported about this time.

ATHERINIDÆ

31—*Menidia menidia notata* (Mitchill) SPEERING, WHITEBAIT

Seined in mid-summer in 1920. Taken in seines from June 21 to September 22, 1921. Very young fry and ripe adults were seen in early part of season, while larger fry and spent adults were seen later.

MUGILIDÆ

32—*Mugil cephalus* Linnæus MULLET, LEAPING MULLET

Common in fall of 1920. A few small examples were taken on June 29, many large ones from July 20 to October 21 during 1921, chiefly in seines and fykes. The adults were exceptionally well nourished and fat. Fowler records this species only from Atlantic and Cape May Counties.

SPHYRÆNIDÆ

33—*Sphyræna borealis* De Kay BARRACUDA

On June 20, 1920, a few very small examples were taken. Three specimens were taken on October 17, 1921 in the seine, two of which measured 16½ and 17 cm. (6½ and 6¾ inches) respectively. Several others of about the same size passed through the meshes at this time.

AMMODYTIDÆ

34—*Ammodytes americanus* De Kay [SAND LANCE, SAND EEL]

A single example, which was probably originally about 5 cm. (2 inches) in length, was taken from the stomach of a small bluefish caught on June 29, 1921. However, it is possible that it was captured at some point outside the Bay. The reason why this common species, abundant at other points close by should be so scarce in this Bay is not clear, although no doubt later in the fall they appear in numbers.

SERRANIDÆ

35—*Roccus lineatus* (Bloch) STRIPED BASS

Fairly common in fall of 1920. One good sized example was taken in seine on June 22, 1921, which was blind, another in a pound net on September 19, and several small and medium ones were taken in fykes between October 17 and 21.

36—*Morone americana* (Gmelin) WHITE PERCH

Common in fall of 1920. Taken in fykes and pounds. A few medium sized examples were taken in fykes between October 17 and 21, 1921.

37—*Centropristes striatus* (Linnæus) SEA BASS

Taken in late fall of 1920, but not common. After their first appearance on September 28, 1921, this species increased in numbers until the close of the season, at which time they were abundant.

LOBOTIDÆ

38—*Lobotes surinamensis* (Bloch) TRIPLE-TAIL, FLASHER

One large, very dark example was taken in one of the outermost pound nets on July 13, 1921.

HÆMULIDÆ

39—*Orthopristes chrysopterus* (Linnæus) PIGFISH

A single individual was taken during 1920.

SPARIDÆ

40—*Stenotomus chrysops* (Linnæus) PORGY, SCUP

A few adults were taken during 1920. Common from June 1 to 23, 1921, males with running milt; spent fish later, July 14 to October 21, decreasing in numbers as the season drew to a close. From October 10 to 21 many small ones of about 3 cm. (1¼ inches) in length were taken in seines and fykes.

41—*Lagodon rhomboides* (Linnæus) SAILOR'S CHOICE

One example was taken during 1920.

KYPHOSIDÆ

42—*Kyphosus sectatrix* (Linnæus) BREAM

One example was taken in 1920. Fowler's list fails to mention this fish as being known from New Jersey waters at all.

SCIÆNIDÆ

43—*Cynoscion regalis* (Bloch and Schneider) WEAKFISH, BLACKTAIL

Present at all times during both years, increasing in numbers as the menhaden decreased. Sometimes taken in fykes as well as pounds. Many silvery below, while others were more or less golden. The fishermen believe the latter to be visitors from outside waters, while the former are supposed to be residents of the Bay. There was no opportunity to gather accurate data as to the actual cause of the two phases appearing simultaneously, however. Several were examined on June 29, 1921, and a number found to be ripe. Their stomachs contained squid, prawns and the remains of small fish. One example contained what appeared to be a small *Bairdiella chrysura* which in turn held a specimen of *Stolephorus* sp. A few examined on September 14 had fed on menhaden. These weakfish varied in length from 32.5 to 50.5 cm. (13 to 20 inches) and contained fish about 11.5 cm. (4½ inches) long. In most cases three such young menhaden were found in a stomach.

44—*Bairdiella chrysura* (Lacépède) WHITE PERCH

One medium sized example was taken on June 28 and another on September 14, 1921. No distinction is made by the fishermen between this and *Morone americana.*

45—*Sciænops ocellatus* (Linnæus) CHANNEL BASS, RED DRUM

One example 82.5 cm. (2 feet 8½ inches) in length was taken on September 13, 1921.

46—*Leiostomus xanthurus* Lacépède SPOT, LAFAYETTE

Common all season in 1920. Present sparingly all summer in 1921, most plentiful in September, falling off in numbers on either side of that month. Much less common than in the preceding year.

47—*Micropogon undulatus* (Linnæus) CROAKER

Common during 1920, being taken at times by the boat load between June 13 and October 22. One or a few examples were taken on each of the following dates in 1921: June 28, July 7, 28, August 25, September 14, 28, and October 20. Some were of a fair size while some were not over 15 cm. (about 6 inches) in length.

48—*Menticirrhus saxatilis* (Bloch and Schneider) KINGFISH

Only small examples were taken both years, averaging about 15 cm. (6 inches) in length in fykes and seines. Fairly common from July 28 to October 21, 1921.

49—*Pogonias cromis* (Linnæus) DRUMFISH, BLACK DRUM

Two examples were taken in September, 1920. One was about 914 cm. (3 feet) and the other about 1219 cm. (4 feet) in length.

POMATOMIDÆ

50—*Pomatomus saltatrix* (Linnæus)
BLUEFISH (Young—SNAPPER)

Fairly common in 1920. Taken in 1921 from June 21 to October 21. The adults became more common as the season wore

on, with a drop in numbers, however, near the end. The young were common, being taken in seines and fykes as well as the pounds. By October 11 most of the fish hatched early in the spring had reached a length averaging 15 cm. (about 6 inches), which was well established by a comparison of the serial collections, showing this species to have an extremely rapid rate of growth.

RACHYCENTRIDÆ

51—*Rachycentron canadum* (Linnæus) CRAB-EATER

One large example was taken in 1920.

STROMATEIDÆ

52—*Peprilus paru* (Linnæus) HARVEST FISH, BUTTERFISH

Taken in mid-summer in 1920. Adults were fairly common from June 28 to September 17, 1921. Fowler fails to mention this species at all in his list. Apparently an oversight, as it is mentioned in a paper[3] of his of 1906, in which he writes "It is known only from the record of Dr. Abbott. It is properly a native of southern waters and can only be said to be a straggler on our shores." Nichols, writing of the fishes within fifty miles of New York City[4] says "The Harvestfish is occasionally common in summer - - - ." The experience of the writer has certainly confirmed the latter statement and it seems remarkable that as late as 1906 only one record of this species had found its way into regional literature.

53—*Poronotus triacanthus* (Peck) BUTTERFISH

Very common during both seasons. Abundant in fall of 1920. Most numerous during the early part of the season of 1921, their numbers falling off prominently after September 28. Adults and juveniles were seen in approximately equal numbers from June 7, which is an early date for the species, to October 21, 1921.

[3] 1906—The Fishes of New Jersey, by Henry W. Fowler. Report of the New Jersey State Museum, 1905.

[4] Fishes of the Vicinity of New York City, by John Treadwell Nichols. American Museum of Natural History, Handbook Series No. 7, 1918.

CARANGIDÆ

54—*Seriola zonata* (Mitchill) PILOT, PILOTFISH

A few of fair size were taken in 1920, from July 21 to November 8. Only medium sized examples were taken in 1921, mostly less than a foot in length. Seen from July 27 to October 21. Most common in the latter part of August and early September.

55—*Selar crumenophthalmus* (Bloch) [GOGGLE-EYED SCAD]

Two were taken in fall of 1920. A few examples 25.5 cm. (about 10 inches) long were taken on September 14, 1921. Not recorded north of Beesley's Point, Cape May County by Fowler.

56—*Caranx hippos* (Linnæus) JACKFISH, RUNNER

A few were taken in 1920, and several medium sized examples between September 13 and 29, 1921. Recorded from Atlantic and Cape May Counties only by Fowler.

57—*Caranx chrysos* (Mitchill)
YELLOW MACKEREL, RUNNER, GOLDFISH

A few were taken in 1920. Common in 1921, all small and most abundant in September. Taken from August 18 to October 21, 1921.

58—*Alectis ciliaris* (Bloch) THREADFIN, RIBBON FISH

One example was seen on July 29, 1921, and another on August 12, both 10 cm. (about 4 inches) long. Recorded from Cape May County only, by Fowler.

59—*Vomer setipinnis* (Mitchill) MOONFISH, LOOKDOWN

A few small ones were taken in 1920. Two fair sized examples were taken on July 14, 1921, and another one of about 4 cm. (1½ inches) on October 17. Fowler records this from Cape May County alone.

60—*Selene vomer* (Linnæus) MOONFISH

Recorded in 1920.

61—*Trachinotus carolinus* (Linnæus) POMPANO

Several large examples were taken in fall of 1920 as well as a few small schools of young fish. Many small examples 7.5 to 10 cm. (about 3 to 4 inches) were taken in seines and fykes from September 27 to October 18, 1921. Scattering small individuals were taken from September 27 to October 21, 1921. Much more common than the preceding year.

SCOMBRIDÆ

62—*Scomber scombrus* Linnæus MACKEREL

A few were taken in 1920. A few large and many small examples, 15 to 21.5 cm. (6 to 8 inches) were seen June 7 to July 8, 1921, while from September 18 to October 21, only small ones were observed. Taken in all gear. Small ones 65 to 120 mm. (about $2\frac{1}{2}$ to $4\frac{3}{4}$ inches) taken on July 7 were found to contain schizopods, copepods, amphipods, *stolephorus* sp. and other mangled small fish.

63—*Scomber colias* Gmelin MACKEREL

Recorded in 1920.

64—*Sarda sarda* (Bloch) BONITO, HORSE MACKEREL

A few dozen examples 914 cm. (about 3 feet) long were taken between September 13 and 17, 1921.

65—*Scomberomorus maculatus* (Mitchill) SPANISH MACKEREL

One medium sized example was seen on August 25, 1921.

LABRIDÆ

66—*Tautogolabrus adspersus* (Walbaum) CUNNER, BERGALL

A few were recorded in 1920. Three small examples were seined in "Dredged Pool" on July 21, 1921.

67—*Tautoga onitis* (Linnæus) BLACKFISH

Fairly common in the fall of 1920. Large and medium examples were taken in pounds in 1921, and by seines in tide pools rather sparingly all season, but becoming more common with the approach of cold weather.

BALISTIDÆ

68—*Balistes carolinensis* Gmelin TRIGGERFISH

Several small examples were taken in 1920. Two fair sized specimens were taken on October 17, 1921, which is a late date for this species.

MONACANTHIDÆ

69—*Stephanolepis hispidus* (Linnæus)
FILEFISH, GRANNY WHALE

Several were taken in 1920. A few small examples were taken from September 13 to October 12, 1921.

70—*Alutera schœpfii* (Walbaum) GRANNY WHALE, HAMBAG

A few large and several small examples were taken in 1920. One large specimen was taken on July 28, 1921, and many small ones, about 20 cm. (8 inches) long, with juvenile markings from then on to October 21. Recorded by Fowler from Atlantic, Cape May and Ocean Counties only.

TETRAODONTIDÆ

71—*Lagocephalus lævigatus* (Linnæus)
RABBITFISH, SMOOTH PUFFER

One dead specimen was seen in the possession of a fisherman on September 15, 1921.

72—*Spheroides maculatus* (Bloch and Schneider)
SWELLFISH, SWELLTOAD, TOADFISH, PUFFER, PUFF-BALL

Common practically all season in 1920, but less so in fall. Common from June 1 to July 15, 1921, becoming scarcer toward the latter date. Many of these fish were nearly ripe and some of the females emitted ova. Later, July 27 to October 21, young were taken in seine from 2.5 to 13 cm. (about 1 to 5 inches) and longer, while adults were irregularly abundant, but all apparently were spent.

DIODONTIDÆ

73—*Chilomycterus schœpfii* (Walbaum)
SPINY PUFFER, BURRFISH, PINCUSHION

Not rare during the fall of 1920, and a single specimen was taken as early as July 27. One large example was reported on July 8, 1921, which is an early date, and small ones fairly common from September 13 to October 21. These latter averaged 10 cm. (about 4 inches) in length.

MOLIDÆ

74—*Mola mola* (Linnæus) HEADFISH, SUNFISH

A few were reported by fishermen in 1920. One small specimen was reported on June 22, 1921, and others were mentioned by fishermen about this time.

COTTIDÆ

75—*Myoxocephalus octodecimspinosus* (Mitchill)
DADDY SCULPIN

A few were taken in the spring and fall of 1920.

TRIGLIDÆ

76—*Prionotus carolinus* (Linnæus) SEA ROBIN

A few were seen occasionally all through both seasons but not as common as the following species; medium and small examples only. In 1920, some as long as 20 cm. (about 8 inches) were seen in the autumn.

77—*Prionotus evolans strigatus* (Cuvier and Valenciennes)
SEA ROBIN

Common both years. Seen from June 21, 1921, to season's end. None above medium size. Small examples, 10 cm. (about 4 inches) in length abundant in latter part of season.

ECHENEIDIDÆ

78—*Echeneis naucrates* Linnæus
SUCKER, SHARK SUCKER, PILOT, FISH SUCKER, SUCKING FISH

One was taken on October 11, 1920, which is a late date. Several medium sized examples were taken from July 7 to 15, and 27

to 29, 1921. It is likely significant that their appearance was made only when *Carcharhinus milberti* was also present during this year.

BATRACHOIDIDÆ

79—*Opsanus tau* (Linnæus) SALLY GROWLER

Medium and small examples were taken in all inshore nets at practically all times both years, but most common in fall. Taken in all gear in 1921, from September 13 to October 21. None of the fishermen encountered knew this species as Toadfish, the appellation generally given it elsewhere.

MERLUCCIIDÆ

80—*Merluccius bilinearis* (Mitchill)
LING, HAKE, SILVER HAKE, SQUIRREL HAKE

Taken in spring and fall of both years. Seen on June 1, 1921, and from October 17 to 21, being absent during warm weather. In spring the specimens were of good size, while in fall they were small, being about 20.5 cm. (8 inches) long. At no time was this species very common.

GADIDÆ

81—*Microgadus tomcod* (Walbaum) TOMCOD, TOMMYCOD

Taken in fall of 1920. One example was taken on July 21, 1921, in "Dredged Pool" and a few in fykes from October 17 to 21. All small fish.

82—*Gadus callarias* Linnæus COD, (Small, up to 2 feet—SCROD)

Taken in lobster pots at mouth of the Bay during November and possibly later in 1921. First reported November 1. Fish 45 cm. (about 18 inches) long. A few taken in the outermost pounds.

83—*Phycis regius* (Walbaum) HAKE, LING

A few were taken in the fall of 1920.

84—*Phycis chuss* (Walbaum) HAKE, LING

Taken in spring and fall of 1920. Taken in spring of 1921. This, like the less common preceding species, disappears in warm weather. One example examined on June 1 was found to be crammed full of large prawns.

PLEURONECTIDÆ

85—*Paralichthys dentatus* (Linnæus) FLUKE

Fairly common at all times both seasons. The largest individual recorded measured 60 cm., 24 inches in standard length, 67.5 cm., 27 inches in total length, and was a spent female. It was seined on June 21, 1921. Small examples 5 to 15 cm. (2 to 6 inches) frequently were taken in the seine, while most of the large ones were met with in the pounds, and occasionally in the fykes.

86—*Pseudopleuronectes americanus* (Walbaum) FLOUNDER

All small examples taken both years, varying from 5 to 20 cm. (about 2 to 8 inches) in length. Taken throughout the season of 1921 and chiefly in seines.

87—*Lophopsetta maculata* (Mitchill) WINDOWPANE

Plentiful both seasons, none seen over 18 cm. (7 inches). Absent in August and September of 1920, but present at all times in 1921. The stomach contents of several examined on June 1, 1921, consisted of crustacean remains, probably schizopods. On August 25, a small example was seined in which the right side was almost as well pigmented as the reverse. Only the under part of the head and abdominal region was white, the remainder duplicating the normal color of the left side. Fowler does not record this species from Monmouth County.

88—*Etropis microstomus* (Gill) [SMALL-MOUTHED FLOUNDER]

One example, 7.5 cm. (about 3 inches) long was taken in a seine on September 28, 1921. This species is not included in Fowler's list as being known from Monmouth County. Deposited in the American Museum of Natural History.

SOLEIDÆ

89—*Achirus fasciatus* Lacépède HOG CHOKER

One example of 15.5 cm. (about 6 inches) in length was taken on July 6, 1921.

LOPHIIDÆ

90—*Lophius piscatorius* Linnæus

CARPET BAGGER, ANGLER, TOADFISH

A few were taken in the fall of 1920. Two examples, each 76 cm. (about 2½ feet) long were taken on October 20, 1921.

In concluding this list a few remarks on general considerations may not be amiss. As might be expected, the pound nets lying nearest to the shore were found to usually capture the smallest specimens as well as the majority of typical shore loving fishes, while those further out most often caught the largest examples and also contained the highest number of pelagic forms. In addition the latter took nearly all the southern representatives, which reach here in the latter part of summer and early autumn. The combination of a large number of factors is responsible for the above mentioned condition, but probably chief among them are, salinity, temperature, and water currents. A through study of these three elements would almost certainly throw considerable light on the problem of the distribution of the fishes of such a small bay as this, besides adding something to the knowledge of the life histories of a number of species.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II, NUMBER 16

THE WEAVING OF THE RED-BILLED WEAVER BIRD IN CAPTIVITY

By HERBERT FRIEDMANN

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

AUGUST 23, 1922

First form on press August 23, 1922.

INTRODUCTION

It is among the weaver birds that we find the art of nest-building developed to its greatest perfection. Their nests are models of bird architecture and represent the climax of avian effort at home making.

"Instinct and necessity have made these birds wonderful architects. Natives of a land where the rays of a vertical sun alternate with tropical rains; where monkeys, serpents, and all kinds of other enemies abound, the weaver bird has learnt to avoid these manifold dangers for his progeny. . . . In its details the nest of each species of weaver bird varies, but all of them are more or less ball-shaped. The roof is always very thick and substantial enough to keep off the heaviest downpour, as well as to protect the inmates from the tropical sun. The nest is invariably suspended from frail branches or reeds just strong enough to bear its weight, but never strong enough to tempt any predatory animal to climb up. The entrance to the nest is invariably from underneath, a sort of ridge dividing the nest proper from the entrance, and preventing eggs or young from falling out. No bird of prey can therefore possibly see the contents of a weaver bird's nest, much less commit any ravages on a brood." [1]

Review of the Literature

For a long time ornithologists have been interested in the nests of the Ploceidae and while a great deal has been written about them, no one, as far as I have been able to ascertain, has ever described the actual details of the methods of nest construction in any species of weaver birds, or, for that matter, in any species of bird. This may seem to be a hasty statement, but a thorough search in the literature of this subject has failed to produce a single article of the nature sought for, the nearest and best attempts being those conveniently collected by Dr. A. G.

[1] B.ackston, W. A., Swaysland, W., and Wiener, A. F. The Book of Canaries and Cage Birds, British and Foreign, p. 404.

Butler in his work on "Foreign Finches in Captivity."[2] But these deal only with the larger features of nest-building. Plenty of good descriptions of these larger features have been published for many of the Ploceidae, notably those just referred to, those in the works of Shelley,[3] Chapin,[4] Stark and Sclater,[5] Bates,[6] etc., to mention just a few of the more important ones. Bartlett's unfinished monograph of the weaver birds does not go into as great detail in the matter of nidification as a monograph might, and, as far as the present paper is concerned, adds nothing to those mentioned above.

As far as the particular species under discussion in this paper, *Quelea quelea* (*Quelea sanguinirostris*), is concerned, good descriptions of its nesting habits have been published by Blackston, Swaysland and Wiener,[7] by Butler, Shelley, and others, but all, as I said before, deal only with the gross aspects of the building process.

In view of the lack of the literature on this point, it may not be amiss to present herein a study of the actual weaving of one of the commonest species of Ploceidae, the Red-billed Weaver.

---

[2] Butler, A. G., 1899, Foreign Finches in Captivity.
[3] Shelley, G. E., 1896, Birds of Africa, Vol. IV.
[4] Chapin, J. P., 1917, Classification of the Weaver birds. Bull. A.M.N.H. Vol. XXXVII, Art. IX, pp. 243-280.
[5] Stark and Sclater, Birds of South Africa, Vol. I.
[6] Bates, G. E. Ibis., Jan., 1909, p. 44; Ibis, 1911, p. 589.
[7] See[1] pp. 408-409.

FIG. 130. WEAVING OF WEAVER BIRDS IN THE PERCHING BIRDS HOUSE IN THE ZOOLOGICAL PARK

1. Nest recently started showing vertical loop. 2. Completed nest. 3. Part of playground. Photographed two years after the studies were made.

THE WEAVING OF THE RED-BILLED WEAVER BIRD, *QUELEA QUELEA* IN CAPTIVITY

By Herbert Friedmann

1. General Features of Nest-building

The general features of nest construction in this species have been described in more or less detail by several writers referred to above. Therefore I shall pass over this phase of the subject in a hasty manner and, were it not for the fact that in captivity the birds build nests quite unlike those built by the same species in nature, I would scarcely have touched upon it.

Not only did the nests built in the Zoological Park differ from those in nature, but also from those built in the aviaries of Dr. A. G. Bulter in London where, to judge by his descriptions, the nests built in captivity agree with those built in a state of nature. I cannot, and do not attempt any explanation for the discrepancies between the nests in captivity as I found them and those in nature or in the London aviaries.

In nature, the nest of the species is described as a more or less globular nest with an entrance hole on one side. In captivity the nest was really cup-shaped and had an arched roof which was attached to the nest proper at the two ends of the major axis of the slightly elliptical margin of the cup, and free on the sides. If the roof had been adnate to the bowl around its entire edge, the nest would have been truly globular. Mr. Chapin, whose wide field acquaintance with the Ploceidae gives his statements the stamp of authority, writes me that "ordinarily no weaver would leave a part of the roof open as in your sketch. Building is generally begun by weaving an upright ring at about the middle of the nest-to-be, and then adding the back of the nest, and the front, with entrance. So far as I know they never begin by constructing a simple cup-nest like a vireo."

In Reichenow's Vogel Afrikas III, p. 109, von Heuglin is quoted to the effect that while the subspecies *aethiopica* built

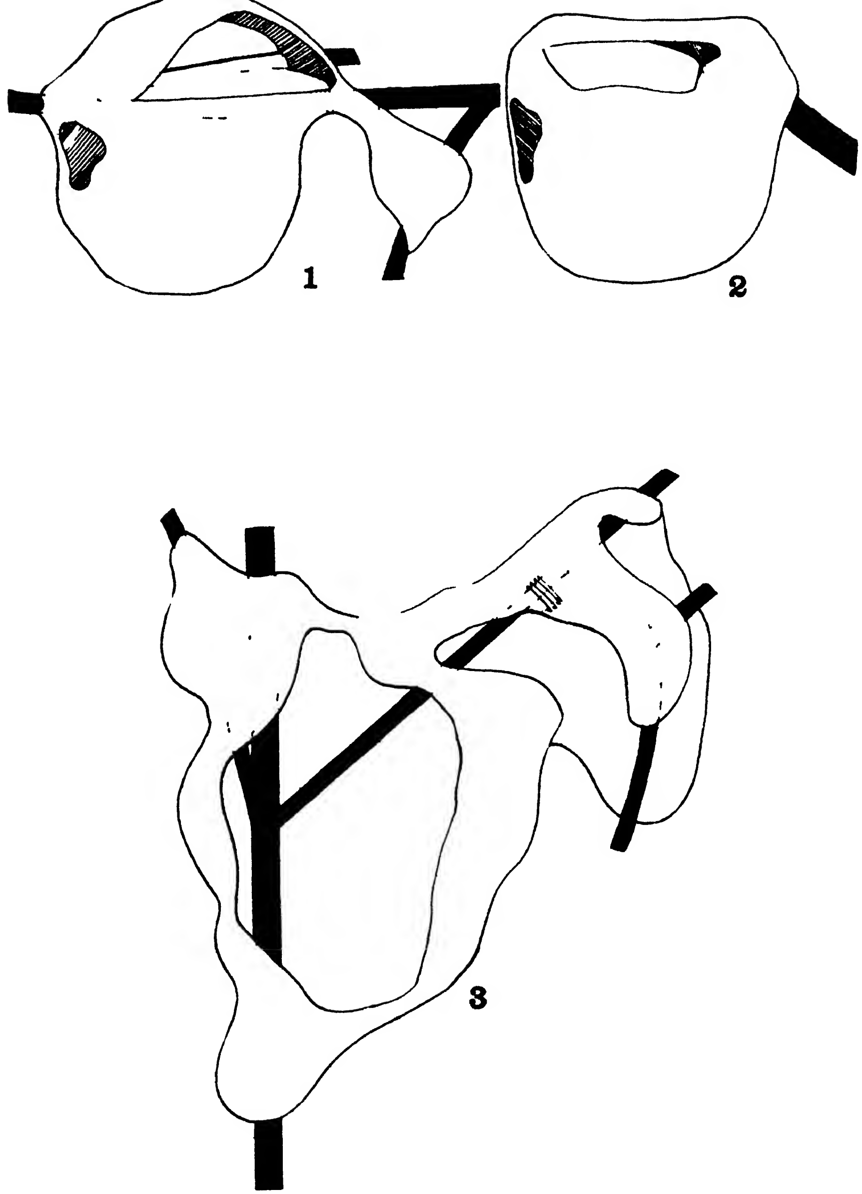


FIG. 131. OUTLINE DRAWINGS OF TWO NESTS AND PART OF A PLAYGROUND BUILT IN CAPTIVITY

purse-shaped nests in the Gardens at Khartoum, especially in Parkinsonias, they seemed never to lay in them.

The South African species is said to be parasitic. This is probably an error.

The two nests built by this species in captivity and part of the "playground" are shown in outline sketches (Fig. 131). It will be noticed that the two nests are very dissimilar in the degree of curvature of the roof but that they agree in having the roof partly free on the sides. The "playground" consists of perches, arches and runways, connecting the nests.

When building, *Quelea quelea* usually selects a fork of a branch and weaves a small mass of fiber or whatever material it may have (raffia in this case) right in the crotch of the fork. From this as a basis it forms a hoop nearly vertical as a rule. "From this hoop it works, starting from the bottom and gradually filling in the back, finishing off with the front, in the center of which it leaves a small hole to enter by." [6]

2. Details of Weaving

At the time this study was begun, there were nests already built, and also a large mass of what we may collectively call the "playground." This gave the birds two different types of sites for weaving—the first being the bare twigs around which they might weave, the second being the already existing woven foundations (nests and playground), to which they might add by weaving.

There seemed to be different types of stitches employed by *Quelea quelea* when weaving on a previously woven foundation than when weaving around a branch or twig. In describing stitches, I believe that diagrams are clearer and more eloquent than words, and consequently this text is largely an explanation of the accompanying plates.

When weaving around a twig or branch, *Quelea quelea* used three types of stitches as illustrated (Fig. 132). The arrows indicate the direction of the progress in making the stitch; the

[6] Butler, A. G., 1899. Foreign Finches in Captivity, p. 229.

dotted lines represent the strand of raffia as being on the far side of the twig, i.e., the portion that would be hidden by the twig in this view. (1) shows what seems to be a stitch used chiefly in conjunction with that shown in (2). Here the bird places a strand longitudinally along the branch, pushes one end around the twig, catches it on the other side, carries it up and over, tucks it under the part of the strand lying lengthwise along the branch, pulls it through and then tightens it with jerks of its head, seizing the strand nearer the knot with each jerk, until the knot is tight. In all weaving, the bill is the weaving organ, taking the place of a hand, the feet being used merely to clamp the straw down to the twig and hold it there.

In (2) is illustrated the simplest and most commonly used of all the stitches. The diagram should be self-explanatory, the stitch consisting in merely laying a strand longitudinally along a branch for about half its (the strand's) length and winding the remaining half around and around to hold it there. When the end of the strand is reached it is tucked in as in (1).

A variation of the type shown in (1), is illustrated in (3). This type is apparently rare as it was seen but once out of hundreds of stitches observed. It was used to tuck in the end of the strand at the completion of a stitch of the type shown in (2). All these three types were used when weaving on straight limbs.

When weaving at a fork the birds did one of two things: Generally they wove a solid compact mass of straw on the two arms of the fork before stretching a single strand across. However, they sometimes, though seldom, stretched a strand across before weaving any foundation on either side. They would straddle the fork, one foot on each side, just as far apart as possible. At times the distance between their feet was more than twice the width of the body! Then they would fasten the ends of the strand on either end by a stitch as shown in (2) and (1), Fig. 132. However, when the birds did act as above, they invariably drew the straw down to the crotch of the fork after they were through. Evidently they have no liking for frail suspension bridges.

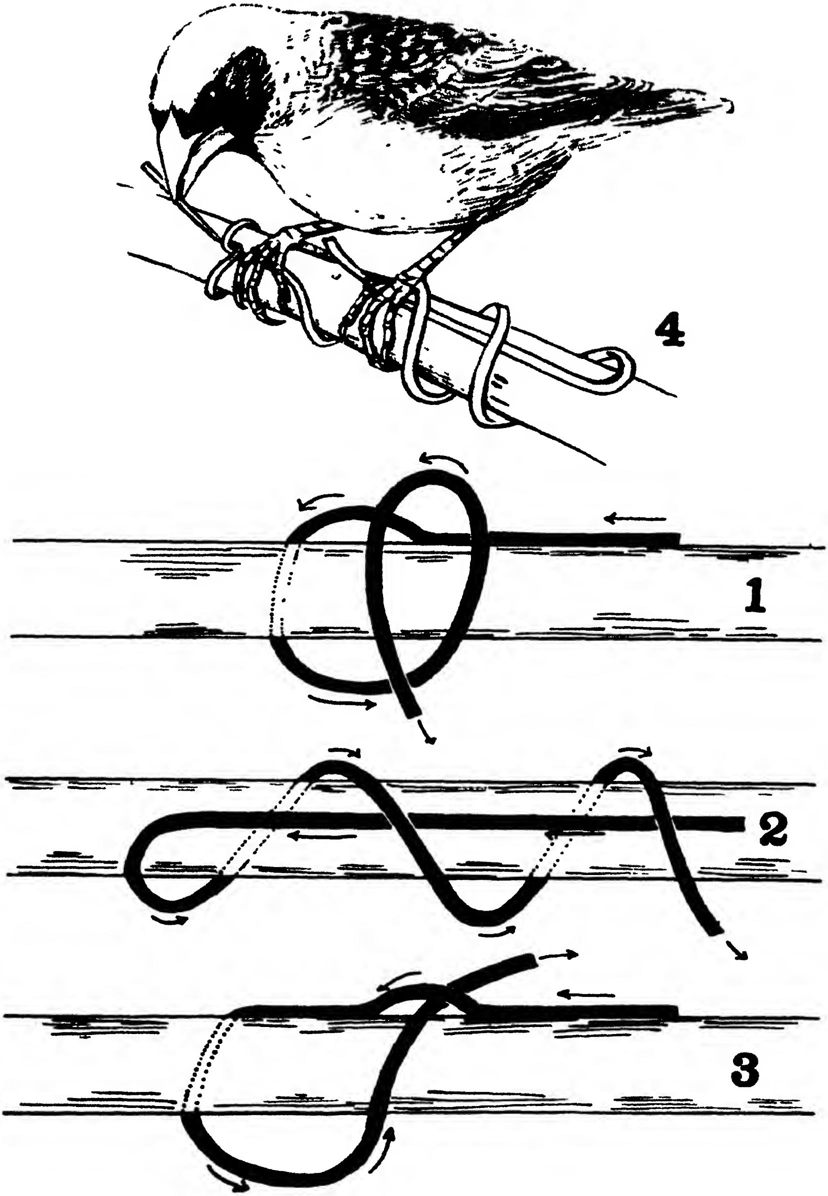


FIG. 132. TYPES OF STITCHES USED BY *Q. QUELEA* WHEN WEAVING AROUND A BRANCH

(4) after drawing by James P. Chapin.

When the birds were weaving on an old foundation of straw previously woven, their stitches were quite different from any of the preceding. In Fig. 133 the stitch is shown in detail in (1 to 10 incl.). The arrows indicate the direction of movement of the straw, dot-and-dash lines represent the straw being pulled through the mass of straw foundation, and dotted lines indicate the straw being on the other side of the mass.

The letter A marks the place in each case where the bill was applied. Briefly, the stitch is as follows: The bird holds a strand near one end in its bill and pushes it through the already existing woven mass (represented in the diagram by the space between the two parallel horizontal lines) as in (1). Bending over, it pulls the strand until one end is through as in (2-4). Then the bird takes the strand around the back of the mass (5-6), and repeats the process (6-9), the next time winding it in front of the mass as in (10). This stitch formed by far the greatest part of all the weaving done by *Quelea quelea.*

Especially interesting are (6′) and (7′) as indicative of the intelligence of these birds. In (6′) the bird made a knot by pulling the strand through the loop. Then on pulling at (A) (6′), to draw the knot tight, the bird evidently noticed that the part of the strand (B) (6′) was being drawn through the woven mass more and more with each tug at (A). The bird then tucked (B) under the loop (C) (7′) and then went back and jerked at (A) without any danger of pulling the strand out!

The weaving done by *Quelea quelea* is not only intricate and beautiful but it is strong and serviceable. I tried to pull down some straw the birds had woven on the wire netting of the cage. In one case the straw was attached only at one end, the other end dangling freely. I pulled with a force that I estimated to be over ten pounds, and the straw broke but the knot did not undo itself! On the contrary it seemed to become tighter.

The speed with which the birds weave is subject to great variation. All the straws used were of approximately equal length (one foot) so that in comparing speed, the comparison was a fair one. The speed varied from forty-eight seconds to

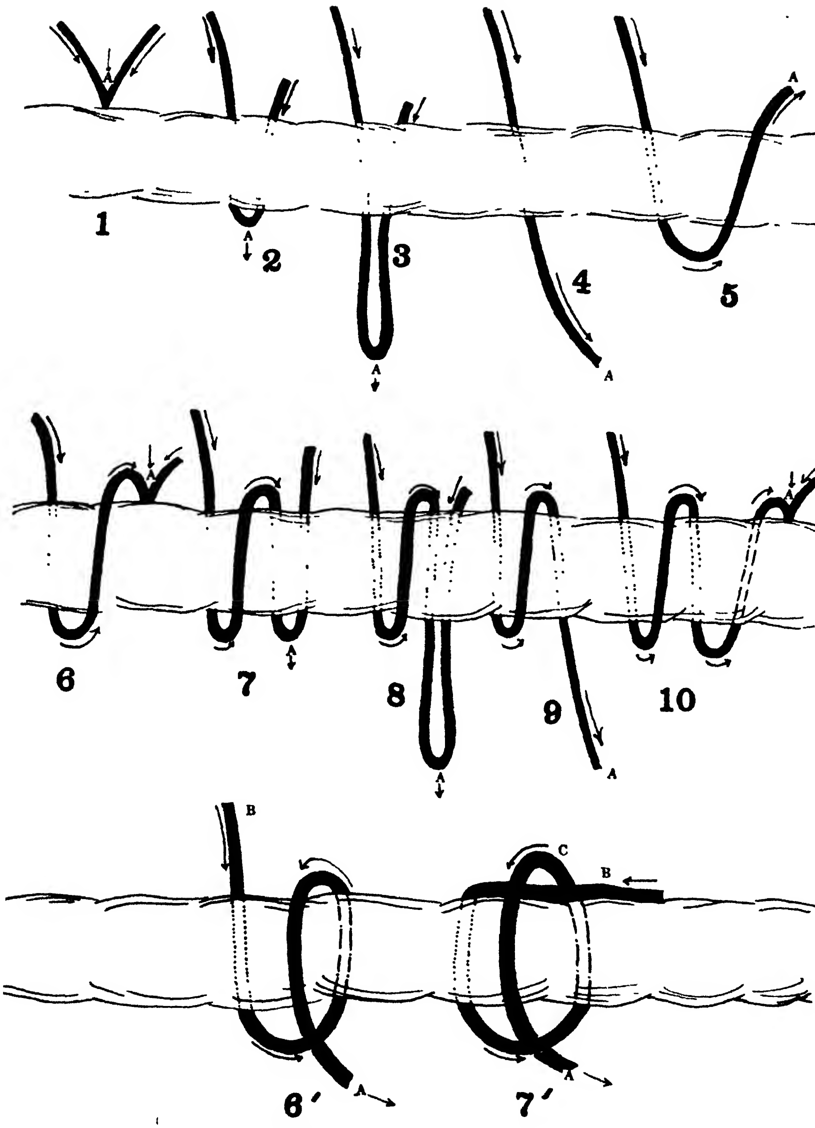


FIG. 133. STITCHES OF WEAVER BIRD OVER AN OLD FOUNDATION.

over thirty minutes per straw. Of course in winding around two twigs it would naturally take less time to use up a straw on a twig of greater diameter than on a smaller twig, there being fewer revolutions necessary in the former case.

The relation between the bill and the feet in weaving is interesting. The birds always pick up the strands with their bills, but invariably hold them down on the twigs or woven masses with their feet. A highly specialized case of correlated action is shown in Fig. 134. The bird pushed the strand underneath its toes as in (1-3). Then it took one end of the strand around the twig as in (4), and tried to push it under between its toes. (4A) shows the same position as (4) but from another view. Then to facilitate matters, the bird raised its middle toe, thereby loosening the straw and allowing the bill to work its way under and make the knot. This was observed but once, so that it is evidently not a general practice with *Quelea quelea,* but nevertheless serves to emphasize the degree of skill and intelligence with which these birds are endowed.

The discrimination shown by these birds in their nest making is little short of amazing. The location for permanent weaving is chosen only after many trials of various places. They are extremely critical of their weaving, often pulling out part of their nests and weaving it over again. In one case a bird pulled the same straw out eight times before it was satisfied with the manner in which it was woven. The general practice was this: A bird would weave in a strand, wipe its bill on the twig and then view its work from all sides. Then if not satisfied, it would try to mend it or pull it out entirely and try again. The weaving had to be compact or it was not satisfactory. Often the birds would pull and pull at a straw, each time jerking their heads back and forth with such force that it was a wonder that they could stand the strain. The discrimination of *Quelea quelea* with regard to color is fully described under Color Preferences. Suffice it to say here that red was the favorite color and orange next, while green, black, blue and violet were not used to any great extent.

The birds also showed considerable discrimination with regard to the width of the straws used. They preferred thin, fine

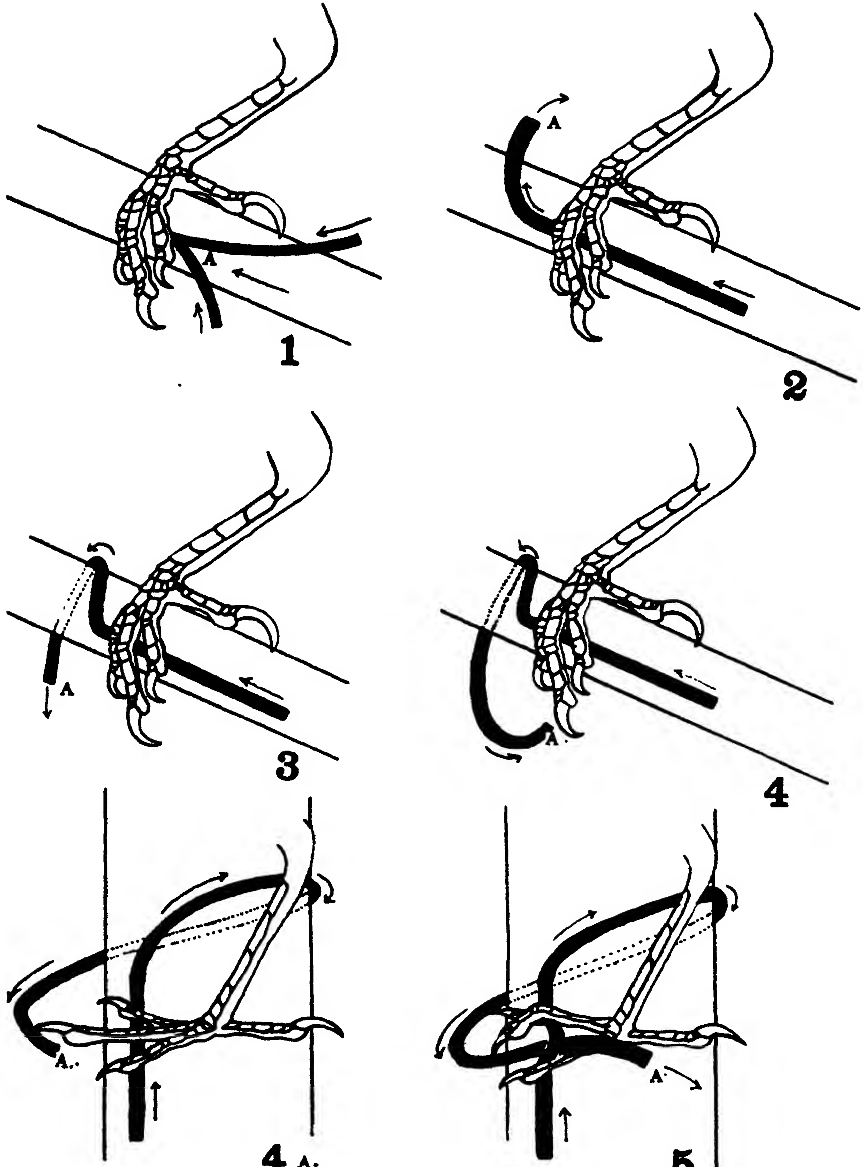


FIG. 134. HIGHLY SPECIALIZED CORRELATED ACTION BETWEEN BEAK AND FEET.
(1-4) Figure of foot after drawings by James P. Chapin.

straws to coarse, heavy ones. In fact, on numerous occasions, after stretching a strand across a fork, a bird would peck at the middle of the strand until the raffia would split longitudinally. Then it would pull on one side, thereby elongating the split until the entire length was divided into two thin strands where there had been but one wide strand. *Quelea quelea* is about as active and tireless a nest builder as one can want. The birds are always building new nests or playgrounds and when they have no building material, they busy themselves with repairing or even tearing down the old nests only to rebuild them and tear them down again. In his activity and "restless anxiety to weave nests, anything comes handy to the Red-beaked Weaver-bird, and a small finch coming near him would at once find himself minus a wing or tail feather, a friendly pecking at the neighbor's plumage being more convenient to the Red-billed Weaver than a search after a bit of fibre."[9]

This restless desire to build seems not to be restricted to *Quelea quelea* for Bates[10] writes of *Ploceus cucullatus* that ". . . . . . tearing down their nests only makes them build the more furiously. They have a perfect mania for building, and when not building new nests are all the time repairing the old ones. They often destroy palm trees by stripping them bare of their leaves."

There was much keen rivalry between birds for straws. If one bird picked up a straw and dropped it, another bird was sure to pick it up in preference to any other straw, regardless of color or width. It was not uncommon to see two birds, one on each end of the same strand pulling in opposite directions. The birds sometimes tried to frighten each other away from their nests by spreading out their wings, somewhat in the style of the intimidation display of the white-breasted nuthatch, as described by Allen[11], lowering the head, opening wide the bill and uttering a harsh scolding note.

[9] Blackston, W. A., Swaysland, W., and Wiener, A. F. Book of Canaries and Cage birds, British and Foreign, p. 404.

[10] Bates, G. L. Ibis, Jan., 1909, p. 44.

[11] Allen, A. A., Bird Lore, Vol. XXI, No. 1.

The presence of crowds of people tended to make the birds more active, as on Sundays when thousands of people watched them during the day. Ordinarily the birds were most active from 10:00 A.M. to 11:00 A.M.; least active, or rather inactive from 11:00 A.M. to 2:00 P.M.; and active again from 2:00 P.M. to 4:00 P.M. If no crowds were present the birds would tend to sleep from 11:00 A.M. to 2:00 P.M., a habit reminiscent of their lives in tropical Africa.

Color Preferences

In studying the stitches used by the birds it was found convenient to use various colors of raffia so that each stitch would be easy to follow through. Incidentally it was found that the birds seemed to have a definite preference for certain colors, chiefly red and orange.

In testing for color preferences, the method used was as follows: Seven colors of raffia were used, the raffia being of exactly the same texture as the raffia the birds had been using for some months previously. The colors used were red, orange, yellow "natural," blue, green, violet and black. There was no noticeable difference between these straws in any respect except as to color. They were tested for taste and no difference in taste was found for any color. They were tested for weight, and found alike. Tests were also made for strength and texture, and all gave similar results. Therefore it was safe to say that the straws were exactly alike except in color. (The term straw as used in this paper refers to a piece of raffia. The term is used merely for convenience.)

Thirty-six equal sized pieces of each color raffia were distributed over the floor of the cage at the end of the day, care being taken to see that the colors were evenly scattered. The birds did not venture to touch the strange material until the next morning. By watching them all the next day (from 10:00 A.M. to 4:00 P.M.), I was able to record just how many pieces of each color each species took, used or rejected. Then, at the end of this day, I added to the raffia previously put in, the same number of pieces of each color as the birds used up during the day.

This was repeated each day for four days. Then the ex-

periment was repeated nineteen days later and carried on for three days. Thus every day the birds had thirty-six pieces of each of the seven colors or two hundred and fifty-two pieces of raffia in all to start with. Therefore, by adding together the results of the different days' tests for each species, I was able to find what colors each preferred and what each disliked. The possibility of the birds using up the colors of their preference and then, through lack of these, having to use other colors was eliminated by starting them off in the beginning with more of each kind than they could use up in a day and by adding each day just what they used up as described above.

All the straws used in the experiments were of equal thickness and about a foot long, this length being chosen because it satisfied two conditions: it was long enough for the birds to use with comfort, and at the same time it was short enough to enable each bird to use quite a few pieces each day. This latter condition was essential if any appreciable number of records were to be obtained.

The experiments were extended not only to include *Quelea quelea,* but also its close relative *Quelea russi,* the Russ masked weaver bird. There were five individuals of the Red-billed Weaver and three of the Russ Masked Weaver under observation. The following table illustrates graphically the substance of the present paragraph:

RED-BILLED WEAVER, *Quelea quelea*
(5 individuals)

	RED	ORANGE	YELLOW	GREEN	BLUE	VIOLET	BLACK
Used	59	27	22	8	11	7	3
Rejected	0	0	3	10	3	5	2
Total	59	27	25	18	14	12	5
Percentage Used	100	100	88	44	78	58	60
Percentage Rejected	0	0	12	56	22	42	40

Russ Masked Weaver, *Quelea russi*
(3 individuals)

	RED	ORANGE	YELLOW	GREEN	BLUE	VIOLET	BLACK
Used	21	20	7	3	1	3	3
Rejected	0	0	0	3	1	0	0
Total	21	20	7	6	2	3	3
Percentage Used	100	100	100	50	50	100	100
Percentage Rejected	0	0	0	50	50	0	0

It will be seen at a glance that in numbers of straws used by *Quelea quelea,* red is more than double orange which, in turn, is greater than yellow, etc. In numbers of straws rejected, that is, picked up by the birds and then voluntarily (apparently) rejected, green leads with ten, while red and orange were never rejected. In this connection I may say that I counted as rejected those straws, the rejection of which appeared to be voluntary on the part of the birds. Several times a bird picked up a straw and was chased by another bird or frightened by some noise, and dropped the straw and flew off to a perch. These cases are not counted here, as they evidently have nothing to do with color rejection. Several red and orange straws were rejected in this way. In view of this it may be that the figures given in the table are not wholly correct but the general results are probably very nearly true. While the preferences may not be as marked as the figures would indicate, we must admit the existence of these preferences. The accompanying graph (Fig. 135) represents the color preference of *Quelea quelea* as interpreted by the number of straws of each color used by that species.

If we add the number of straws used and the number rejected for each color and then find that what not that percent of the total number of each color was used we find the preference to be:

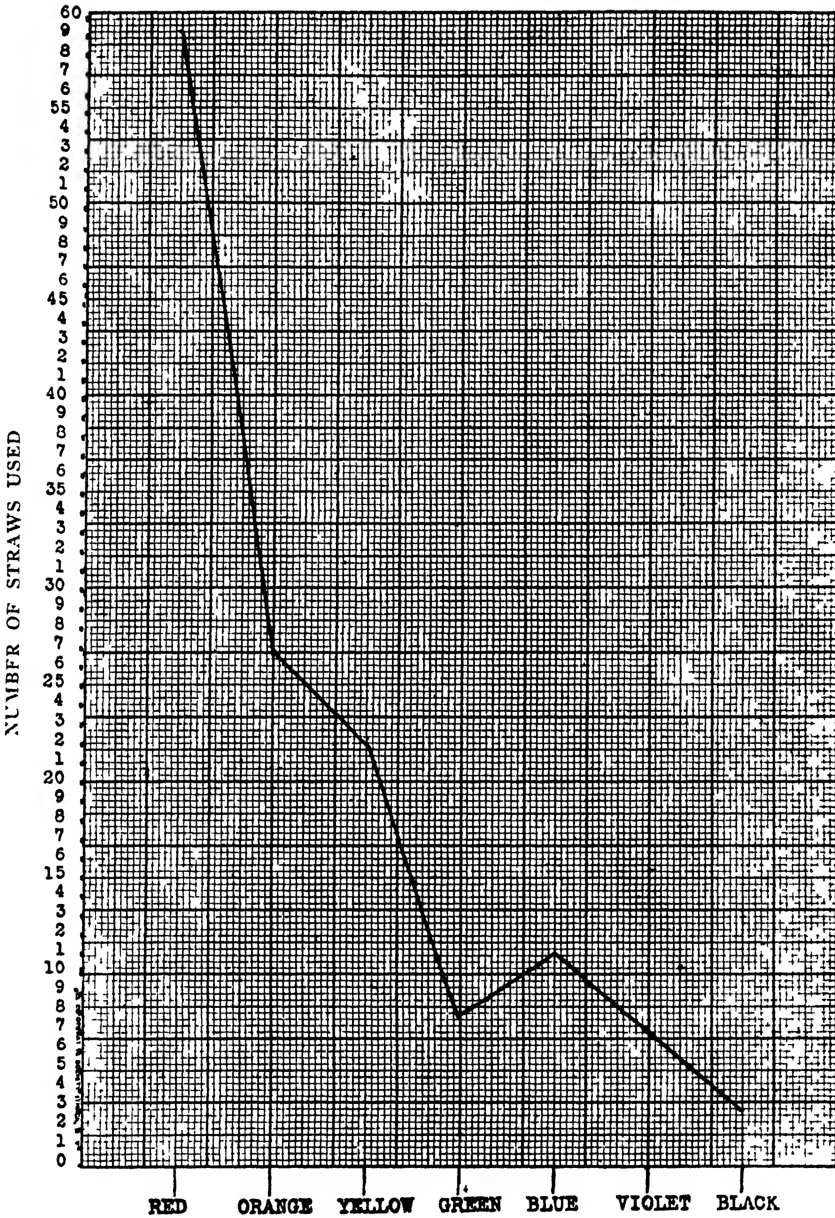


FIG 135 GRAPH SHOWING COLOR PREFERENCES OF *Q QUELEA*

1. *Quelea quelea*—red 100%, orange 100%, yellow 88%, blue 78%, black 60%, violet 58%, green 44%.
2. *Quelea russi*—red 100%, orange 100%, yellow 100%, violet and black 100% (not significant as there were only three straws of each color picked up as compared with twenty-one red and twenty orange), and green 50%, blue 50%.

While there seems to be a fairly well defined color preference for each species, yet there is considerable variation among the individuals of the same species. Thus, one individual of *Quelea quelea* used in one day one red, one orange, one violet, and one blue straw, while another individual of the same species used in the same day three red, three orange, one yellow (and rejected one yellow) and one green straws. Still another individual of this species used on the same day four red, one orange, one yellow, and one blue straws. Yet each individual, of the five used at least one red and no more than one of any other color except orange on that day. Not only is there variation between individuals of the same species, but the same individual may vary from day to day.

Summary and Conclusions

1. In captivity the birds built abnormal nests, but later (two years after), they built normal ones. as shown in Fig. 130.

2. Normally they begin by weaving a vertical hoop, and, beginning at the bottom, fill in the back and then the front, in the middle of which they leave an entrance hole.

3. Different types of stitches were used in weaving on bare twigs and on previously woven masses.

4. In weaving around bare twigs, three types of stitches were used, as shown in Fig. 132. On this plate (2) shows the commonest stitch used.

5. The type of stitch used in weaving on a previously woven mass is shown on Fig. 133 and needs no further mention here.

6. All actual weaving is done with the bill; the toes being used to pick up and hold in place the straws used.

7. A considerable degree of correlation seems to exist between the bill and toes in weaving.

8. The birds exhibit a remarkable amount of discrimination in respect to the color and width of the straws used and in regard to the compactness of the weaving.

9. The birds preferred red and orange to all the other colors used, the colors being taken in the following order:

Red-orange-yellow-green-blue-violet-black.

The last three are not significant due to the paucity of records.

Acknowledgments

The work on which this paper is based was conducted at the New York Zoological Park through the courtesy of Mr. William Beebe and Mr. Lee S. Crandall of the Department of Birds. I take this opportunity of acknowledging my indebtedness to both Mr. Beebe and Mr. Crandall for their many kindnesses and to Professor A. J. Goldfarb of the College of the City of New York for helpful suggestions and criticism. For permission to use the figure of a ploceine foot Fig. 134 (1-4) I am indebted to Mr. James P. Chapin of the American Museum of Natural History, the original of this figure having appeared in his paper on the classification of the weaver birds. Mr. Chapin very kindly has given me also a drawing of a Red-billed Weaver, Fig. 132 (4), for use in this paper.

FIG. 16. WHITEFISHES REARED IN THE NEW YORK AQUARIUM
Photograph by Elwin R. Sanborn

Fig. 16—Face Title Page
Zoologica Vol. II No. 1

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME II. NUMBER 17

(Papers from the New York Aquarium)
(Contribution Number 9)

THE WHITEFISHES

(Coregonus clupeaformis)

WHITEFISHES REARED IN THE NEW YORK AQUARIUM

BY IDA M. MELLEN
New York Aquarium

A STUDY OF THE SCALES OF WHITEFISHES OF KNOWN AGES

BY JOHN VAN OOSTEN
Field Assistant, U. S. Bureau of Fisheries

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

JUNE 19, 1923

THE WHITEFISHES

(Coregonus clupeaformis)

WHITEFISHES REARED IN THE NEW YORK AQUARIUM

BY IDA M. MELLEN
New York Aquarium

A STUDY OF THE SCALES OF WHITEFISHES OF KNOWN AGES

BY JOHN VAN OOSTEN
Field Assistant, U. S. Bureau of Fisheries

THE WHITEFISHES
(Coregonus clupeaformis)

REARED IN THE NEW YORK AQUARIUM

By Ida M. Mellen

New York Aquarium

The New York Aquarium is showing a unique exhibit of whitefishes *(Coregonus clupeaformis)* hatched in the Aquarium in January, 1913; unique in that no similar exhibit ever has been seen there or anywhere else. Once or twice whitefishes were reared in the Aquarium to the age of a month, and once to the age of a year; but those now on exhibition—nine years old at the present writing—are the only whitefishes ever reared in captivity from egg to maturity. They are the survivors of a few hundred specimens retained from the fry that hatched out of a consignment of a million eggs received in December, 1912, from the United States Bureau of Fisheries. The eggs came from western Lake Erie waters, and were shipped from the fisheries station at Put-in-Bay, Ohio. The remainder of the fry were distributed to state waters of northern New York and New Jersey.

By checking up our findings with those of other observers, we have learned some interesting facts about whitefishes, the probable age when they arrive at sexual maturity, their longevity, etc. As ours are the only fishes of this species in existence the age of which is positively known, certain biologists engaged in the study of lepidology (the scales of fishes) have been provided with scales from the Aquarium specimens, whitefishes being one of the species in which the age is written in concentric rings on the scales. Of the various kinds of scales in fishes—placoid, ctenoid, cycloid, ganoid or rhomboid, etc.—those which characterize the whitefish are of the cycloid type, *i. e.*, thin, rounded

scales, having concentric rings as just described, and with no spiny projections.

A cycloid scale strongly reminds one of a finger print. It has its central whorl, called the focus, which starts the series of concentric rings, called circuli, and there are lines of radiation called radii. But unlike the finger print, groups of the circuli are marked off in definite dark and light bands, two such bands representing one year of the fish's life. That is, there is a large area of light summer bands and a small area of dark winter bands or annuli, growth being more rapid during the months when temperature is higher and food more abundant.

Dr. Jacob Reighard's assistant in the Department of Zoology, University of Michigan, Mr. John Van Oosten, who is also in the employ of the United States Bureau of Fisheries, made a study of whitefish scales from our Aquarium specimens. One dead fish and three scales from a live fish were sent him each month for twelve months, in order that he might observe progressive changes in the scales of specimens the age of which was known, though it was not to be supposed that fishes that had spent all their lives in captivity, with limited swimming space and little variety in their food, would compare favorably in development with wild fishes. The method followed in removing the scales was suggested by Mr. Van Oosten and consisted in segregating two specimens, removing scales from one fish one month and from the other the next, thus giving each fish a rest of two months between operations. The scales were removed with a small forceps.

Whitefishes are so fragile that they are sometimes killed merely by transference from one tank to another, or by an accidental stroke of the brush when their tank is being cleaned. It was therefore with some trepidation that the writer commenced this series of very delicate operations. The first specimen operated on died within fifteen minutes; but this tragedy was never repeated. All subsequent operations were made on specimens held by the head and tail in a shallow pan of water, the gills being kept continually moist, and great care being taken to remove scales not too near the lateral line (in fact, all scales were removed from a spot about half way between the lateral

line and the back, the section anterior to the dorsal fin being selected); also to remove them rapidly and apply a strong solution of permanganate of potassium at once to the injured spot, returning the fish quickly to the tank. The operation always exhausted the fish and it would lie quite still while the permanganate was poured on. When returned to the tank it floated on its back, breathing hard for a few minutes, then gradually equilibrated itself and recovered.

Mr. Van Oosten found that the scales of the Aquarium whitefishes revealed the stunted growth of the specimens in the growth of their circuli, but by experience he gradually learned that by selecting scales of a certain shape, he would obtain scales which showed the annuli or year-rings so clearly that any inexperienced person could read them with ease. In fact, he had various such people read the scales though they knew nothing about the age of the fish from which the scales were taken. He found that while the circuli are formed throughout the year, the annulus is truly a winter-band, being formed only during the winter months, *i. e.*, after October. All of which is explained in detail in his paper here published.

So many of these notable whitefishes died in 1921 that it was imagined they might have lived the natural span of their existence; yet they had never been observed to spawn. It was hinted that they must have done so and the eggs had been eaten so fast that no one ever saw them; but Mr. Robert J. Lanier, of the Aquarium staff, to whom belongs the honor of having reared these fishes, has kept watch over them all their lives and was entirely certain that they had never spawned. Was it possible that captivity prevented them from attaining sexual maturity? If so, the case was a unique one.

In January, 1922, when the fishes were exactly nine years old, females were observed swollen with eggs which, however, lacked vitality to such an extent that they could not be fertilized! Were these whitefishes reaching sexual maturity and their natural span of life at the same time? It seemed impossible.

The writer knew of only one way to solve the riddle. Dr. Wilbert A. Clemens, of the Department of Biology, University of Toronto, who had also received some scales from the Aquarium

specimens, had studied the scales of wild whitefishes. Perhaps he had found some that were older than ours! We wrote him about the eggs, their lack of vitality, the supposition that nine years might be the natural term of the life of the fish, etc., and asked if he had ever found a wild specimen more than nine years old.

His answer, as the following quotation from it shows, was fraught with interest:

> "I have indeed taken whitefishes much older than those you have at the Aquarium. I spent last summer on Lake Nipigon and according to my records the largest whitefish we took was twenty-one and a quarter inches in length and was at least sixteen years old. I have records of two others about twenty inches in length, which I have recorded provisionally as sixteen and seventeen years old, but possibly eighteen or nineteen.
>
> "We do not know as yet at what age whitefish first spawn. In Lake Erie I suspect it occurs at the end of the fifth or sixth summer. In Lake Nipigon it probably occurs considerably later. On November 11 of last year I received from the spawn-takers on Lake Nipigon four whitefish which they said were the smallest they had taken spawn from. These were scarcely fifteen inches in length and were nine and ten years of age. So it may be that the whitefish in the Aquarium are just reaching the spawning age, and although the eggs are few and weak this year they may be normal or nearly so next year. It will certainly be interesting to see what happens."[1]

Mr. Van Oosten's paper describes the condition in which he found the sex organs of the Aquarium whitefishes.

This species of whitefish normally attains a length of two feet or more, but none of the specimens in the Aquarium measures more than fifteen inches. We have not infrequently observed that fishes and even snails are stunted by captivity. It is known, however, that fishes do not always stop growing when they reach sexual maturity or decline in years, many continuing to grow as long as they live; and we believe that these whitefishes are still growing, though they probably never will be of normal size.

[1] In December, 1922, when the fishes were nearly ten years old, a female was again observed carrying eggs. She was stripped and the eggs fertilized; but they were weak and did not develop beyond the morula stage.

The last time these specimens were counted was in 1919, when they were transferred from one tank to another and numbered two hundred and sixteen. They have dwindled to about eighty-four, and it is hoped that we may some day be able to repeat the remarkable feat of rearing some to maturity from the eggs—a feat many times attempted both at the Aquarium and at Government hatcheries, but only once performed.

Jordan and Evermann (Fishes of North and Middle America) state that the common whitefish *(Coregonus clupeaformis)* "is subject to considerable variations, dependent on food, waters, etc." The food of fishes is indeed a factor of so great importance in their growth and development that breeders of fancy varieties believe the food controls not only the size and health of the fish, but the actual shape and beauty of its fins. Like other vertebrated animals, they require, for perfect development, foods that are both nourishing and bone-building.

In a state of nature infant whitefishes, judging from those in the Aquarium tanks, remain near the surface for a time, their first food consisting of plankton—live floating matter of both vegetable and animal character: protozoa, diatoms, minute crustaceans such as the young of the shrimp *(Gammarus)* and water fleas *(Cyclops, Cypris, Daphnia)*, etc. Later they subsist entirely on minute crustaceans of these and other species. In the earliest period of their lives, after the absorption of the yolk sac, Dr. S. A. Forbes, of Illinois, has observed that the fry are provided with four curved teeth in the lower jaw, which are of no possible service and are subsequently lost.

Gradually they descend to the bottom for food, and there, according to those who have examined the stomach contents of adult wild specimens, they feed on small live invertebrates, principally crustaceans, snails, insect larvae and water beetles.

The crystalline gray-whiteness of mature whitefishes is exceedingly attractive to the eye, and the specimens in the New York Aquarium have long furnished one of its most pleasing exhibits for the casual visitor, as well as one of its most important economic exhibits for the fish culturist. This species of whitefish is not only the largest, but the most delicate in flavor of all the whitefishes of the Great Lakes.

The Aquarium specimens have never known the excitements of wild life, or what it means to hunt or be hunted.

New York Aquarium, April 1922.

THE WHITEFISHES

(Coregonus clupeaformis)

A STUDY OF THE SCALES OF WHITEFISHES OF KNOWN AGES[1]

BY JOHN VAN OOSTEN

Field Assistant, U. S. Bureau of Fisheries.

INTRODUCTION.

During recent years many investigations of scientific and economic importance have been conducted on the age and the rate of growth of fishes as determined from a study of their scales. This has involved the interpretation of certain rings found on the exterior surface of scales.

In order to illustrate clearly the mode of the formation of these rings, Fig. 137 is presented. It represents a typical scale of a whitefish, 197 mm. in length, captured October 22, 1917, at East Tawas, Mich., on Lake Huron. Near the center of the scale is a small, clear area, the focus (F), which represents the original scale in the young specimen. Around this focus are numerous, more or less relieved striations, concentric or nearly so with the margin. These are termed circuli (C) and like the rings in a tree mark successive stages in the growth of the scale. Running from the focus to the periphery of the scale are four more or less conspicuous radiating ridges (AR, PR), which divide the surface of the scale into four roughly triangular areas or fields. When the scale is in position in the fish the area to the right in the figure is directed towards the tail and is therefore designated as the caudal or posterior area (Caudal). The area opposite the caudal is the anterior (Anterior), while the two areas which separate the caudal from the anterior are the lateral or the dorsal (Dorsal) and the ventral (Ventral). The borders of these four areas which form the periphery of the scale are accordingly termed the caudal, anterior, dorsal and ventral

[1]Contribution from the Zoological Laboratory, University of Michigan, published with the permission of the U. S. Commissioner of Fisheries.

borders. The radiating ridges are either antero-lateral (AR) or postero-lateral (PR). The greatest antero-posterior diameter which bisects the caudal area of the scale is its length (L-L).

By careful examination two distinct zones may be seen in this scale, an inner characterized in general by more closely spaced lines and an outer in which the lines are further apart. The two zones are more readily seen when the figure is viewed from such a distance as to somewhat obscure the details. The inner zone represents, according to current theory, the entire growth of the first year, while the outer zone represents the growth of the second summer. If the lines of growth in the lateral field be followed from the center outward and downward along the antero-lateral ridge, it may be seen that the first twenty are complete and uniformly spaced. With occasional breaks and irregularities they may be traced entirely around the scale. The next six are incomplete and the outermost of them ends (or begins) near the antero-lateral ridge. Following this last incomplete line to the anterior field, a region is encountered within which the individual circuli can no longer be traced with certainty, for they are less distinct, much broken, anastomosed and closer together. This zone of faint, approximated and much broken circuli, when contrasted with the preceding and succeeding areas of strong, complete and widely spaced circuli stands out as a rather sharply defined band. This band may be traced around the whole scale and is perhaps better defined in the posterior field where it appears as a lighter zone with very little detail.

To account for these structures, it is contended that the completed and comparatively widely separated circuli are formed during periods of rapid growth, the incomplete lines during periods of decreased growth, and the short, weak, much broken lines during periods when growth has nearly ceased. As the cessation or retardation of growth is thought to occur in the winter, the much broken area is accordingly designated as a winter-band or annulus (A).

When the scale resumes its growth in the spring a complete circulus is again formed which in the process of uniting, as it were, the incomplete lines bends sharply at the antero-lateral ridge. This circulus is considered the limit of the annulus it encloses and is so employed in the measurements of scales.

The twenty-five circuli of the second summer, in this scale, are much more widely separated than those of the first, which indicates a much more rapid growth during the former season.

Of these twenty-five circuli the last five or six at the margin are incomplete, which indicates the occurrence of a retardation in growth. No approximation of the circuli is yet visible, nor is there apparent the area of weak and broken lines. A complete cessation of growth has not yet taken place. This conclusion appears to be reasonable as the specimen was caught in October preceding the period of low temperatures when growth is greatly retarded or ceases altogether.

The foregoing account of the mode of formation of annuli is accepted by the majority of those investigators who make use of scales in determining the lengths and rate of growth of fishes.

The application of the above hypothesis to the study of the life-histories of fishes is a simple matter. By enumerating the annuli on the scales, the age of the individual is determined in years. Thus the specimen whose scale (Fig. 137) illustrated the method of growth is found to be at the end of its second year. The length of an individual at the end of each successive year may also be ascertained from its scales. Given the total length of the fish and of one of its scales and the length of that part of this scale included in an annulus formed during a given year, the total length of the fish at the end of this given year may be computed by the following formula in which the third term is the unknown:

$$\frac{\text{length of scale formed at end of year X}}{\text{total length of scale}} = \frac{\text{length of fish at end of year X}}{\text{length of fish at the time of capture.}}$$

Repeating this formula for each year of the fish's life, the lengths attained at the end of the several years are calculated and by a simple subtraction the increments of growth for each year are determined.

The soundness of the scale method of determining the length of a fish at successive years of its life and its annual growth increments depends on the validity of the following propositions:

1. That the scales remain constant in number and identity throughout the life of the fish.
2. That the annual increment in the length (or some other dimension which must then be used) of the scale maintains throughout the life of the fish a constant ratio with the annual increment in body length.
3. That the annuli are formed yearly and at the same time each year.

Incidentally the following questions are raised, but the validity of the scale method of computation is not affected by them:

4. Whether the annuli represent periods of retarded or arrested growth of the scale.
5. Whether the growth of the fish in length is retarded or arrested at the time of formation of the annuli.
6. What factors are responsible for the arrest or retardation of growth in fish and scales.

Considering now the first three propositions listed above, it is believed that the first two are fairly well established and that the last one forms the crux of the whole problem. If the age of a fish can be determined with certainty, the establishment of the validity of the third proposition becomes a comparatively easy matter in a group of fishes whose scales show growth rings. Indisputable evidence of a correlation between the number of annuli on the scales and that of the years of life of their bearer can only be obtained by observation on fish of known age in the field and in the laboratory. And the value of the results rises with the number of years for which this correlation is found to exist.

An extended review of the literature is reserved for a later paper. Here I indicate briefly the chief differences of viewpoint.

Both Hoffbauer (1898, 1899, 1901) and Walter (1901) believed that the age-hypothesis does not hold for carp older than four years. Likewise Brown (1904) and Tims (1906) contradicting Thomson (1904) held the scale method entirely unreliable as applied to the Gadidae. Even Thomson concludes from his experiment that a well-fed whiting may pass the winter without forming an annulus on its scales. Arwidsson (1910) concludes from his study of a series of salmon, 4 to 36 months old, that the completion of the first annulus does not occur at a definite time of the year nor at a definite age, but only at a definite length of the fish, viz., at 60 mm. Masterman (1913) asserts that it is a well known fact that the otoliths or "ear-stones" often used for age-determinations cease growing in the plaice after 6 or 7 years, and that scales also are unreliable after the first 4 or 5 years, though the latter statement is questioned by Hutton (1914). Likewise Scott (1906) expresses the opinion that otoliths do not show the exact age of their possessors. Many other authors may be quoted as opposing the age-hypothesis, but an overwhelming majority assume the validity of the theory and apply it.

Much diversity of opinion exists as to the relation between the formation of annuli and the growth of scales and body. The majority of students believe that the annuli are due to seasonal variation in body growth, that they correspond to retarded growth; but Cunningham's (1905) observation and Cutler's (1918) experiments contradict this view in part, while Taylor (1916) denies such a correlation entirely.

Much controversy also obtains relative to the factors governing the formation of annuli. According to Hoffbauer (1898, 1899), Thomson (1904), Fraser (1917) and others food is the primary factor and not temperature. Taylor (1916) and Cutler (1918) conclude from their experiments that food is not the factor involved. Fraser (1917) holds that neither salinity nor density nor temperature has any factorial significance, while Cutler (1918) believes that temperature alone is causative. Rich (1920) refers to the factor as "a changed environment," Jacot (1920) calls it "migration," while in the case of some trout and salmon the later annuli correspond to a spawning and consequently are transformed into "spawning-marks."

Masterman (1913) wrote, "Experience shows that each species of fish must be investigated separately by the method best suited to it," implying that the establishment of the validity of the hypothesis for one species does not necessarily make it applicable to other species of fish.

The scales of the whitefish *(C. clupeaformis)* have never been critically studied. During the course of an extended investigation of the scales of the Coregonine fishes of the Great Lakes, the writer was fortunate in obtaining scales of this species of known age—nine years. This material forms the basis of an attempt to test the underlying assumptions of the scale method of computation as applied to this species. It also is believed to throw light on the relation between annuli and rate of growth; while the accompanying data permit a discussion of the environmental factors involved in annulus formation.

Here I wish to present a brief description of the apparatus used for the measurement of scales, as my method differs from those ordinarily employed. The instrument is constructed on the principle of a photomicrographic apparatus in which the image is projected on the ground glass. The apparatus consists of a rectangular wooden frame, 14 inches square and 34 inches long. Into one end of the frame is fitted, flush with the exterior surface of the frame, a piece of ground glass, 12 inches square. A tapering bellows made of ordinary chart cloth painted black is

attached to the ground glass end of the frame. The bellows when fully stretched extends about three-fourths the length of the wooden frame. The tapered end of the bellows is attached to a small square wooden frame into which is tightly fitted a wooden block in the center of which a hole large enough for the insertion of the microscope tube is bored. When the apparatus is used in the vertical position the microscope is simply placed beneath and extended into the bellows. It is much easier to use this instrument in the horizontal position. In this case the microscope stand is attached to a board at the base of the wooden frame (the end opposite that into which the ground glass is fitted) and the microscope tube drawn into the horizontal position. The open base of the frame is then covered with a sheet of black paper into which a hole is cut so as to allow the light to enter the condenser of the microscope. A special Bausch and Lomb lamp with a 108-Watt bulb furnishes the illumination and is placed about two feet from the base of the frame. A special aspherical condenser accompanying the special lamp is used in the place of the ordinary condenser. The light concentrated upon the hole in the black paper passes through the condenser, microscope tube and bellows, and projects the scale upon the ground glass.

A mechanical stage is always used. To each adjustment button of the mechanical stage is attached, by means of a universal joint cut from a piece of tin, slender wooden rods which extend a little beyond the ground glass end of the frame. In a similar way another rod is attached to the coarse adjustment screw of the microscope. By means of these rods the scale can be moved into place and properly focused from the ground glass end of the frame. The projected scale is measured with an accurate wooden or transparent millimeter rule which is held in place against the ground glass by two strips of steel, four of which are screwed on the wooden frame, one at each corner. To facilitate the counting of the circuli of each scale an ordinary reading glass is used. The whole apparatus is placed upon a long table and may be covered with a black cloth. No dark room is required as the lamp is strong enough to project a clear image on the ground glass in a room illuminated by electric lights; during the day the curtains of the room must be drawn.

The advantages of this method of scale reading over those which use the camera lucida, ocular micrometer or micrometer eyepiece are many. In the first method the scales can be highly magnified without any part being lost to view as is the case in the microscope tube; the circuli and the distances between the

annuli of such highly magnified scales can be more accurately, more quickly, and more easily enumerated and measured; and, if the illumination is properly adjusted, scale work can be done with much less straining of the eyes.

When the apparatus is used in the horizontal position it is necessary that the scales be mounted in a stiff medium. Each scale is therefore cleaned in water with a small bristle brush and mounted in a medium of glycerine to which has been added filtered gelatine and a little carbolic acid. The glycerine and gelatine are mixed in such proportion that the solution will stiffen immediately upon cooling. When in this medium, the scales can be stored as permanent mounts and can also be photographed. The photomicrographs (Figs. 137-142) are of scales mounted in a gelatine-glycerine solution.

I wish to express my appreciation to Dr. Charles H. Townsend, the Director, and to Miss Ida M. Mellen, the secretary and scientific assistant of the New York Aquarium, through whose kindness and efficient cooperation I have been able to obtain the whitefishes and scales for this work. These whitefishes, the only ones known to have been reared in captivity, form a valuable exhibition at the Aquarium so that it has been no small sacrifice to part with even a few of them. I am also indebted to Dr. Walter Koelz of the U. S. Bureau of Fisheries who has kindly given me access to his field data and manuscript on the Coregonine fishes of Lake Huron. I would further express my obligations to Prof. Jacob Reighard, who read the manuscript and generously gave assistance in the course of the work. To Mrs. Alvina M. Woodford, of the University of Michigan Library, I am indebted for many valuable suggestions relative to the photographing of the scales.

NEW YORK AQUARIUM WHITEFISH SCALES

Annuli and Number of Winters of Life

Twenty-seven preserved specimens of the Aquarium whitefish, hatched January, 1913, were received. These had died (or had been killed) at intervals between August 13, 1920, and January 3, 1922, as shown in Table I—a period of sixteen months. The fish received had died (been killed) during every month of the year except November. The lengths of each specimen at the time of death is shown in column K of Table I and is followed by the formula which indicates the sex and the condition of the sex organs (see p. 403). The remaining entries in Table I are calculated values and will be referred to in another place.

Table I—Showing for 27 New York Aquarium Whitefish hatched January, 1913, from eggs from Put-in-Bay Hatchery, the U of M Museum number, the date of death, the length in mm (K) at time of death (measured snout to caudal), the sex and condition of sex organs, the lengths in mm at the end of each winter of life as calculated from the scales (K_1, K_2, K_3, etc), the annual growth increments in mm as determined from scales (k_2, k_3, etc), and the averages of these calculated values for each year of life. Below the calculated averages at the bottom of the columns are given the average lengths and average annual increments for each year of 238 Lake Huron whitefish as determined by actual measurements, the average length of the first year, however, is based on diameter measurements of scales, as no one-year-old whitefish were available

U. of M. Museum Number	Date of Death	Length in mm. K	Sex and Stage of Organs*	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9
54505	Aug. 13, 1920	227	♂ D	55	97	110	142	167	190	217		42	13	32	25	23	27	10	
54506	Oct. 26, 1920	245	♂ D	58	136	152	176	206	218	236		78	16	24	30	12	18	9	
54507	Dec. 1, 1920	265	♂ D	65	131	161	183	210	233	256		66	30	22	27	23	23	9	
54508	Dec. 30, 1920	287	♀ A1-2-4E	108	175	199	219	234	256	274		67	24	20	15	22	18	13	
54509	Jan. 28, 1921	219	♀ A1-2-3D-	63	113	127	143	163	190	206		50	14	16	20	27	16	13	
54510	Feb. 28, 1921	334	?eviscerated	112	201	234	255	277	299	314		89	33	21	22	22	15	20	
54511	Mar. 4, 1921	303	♀ A3D-	67	135	156	196	222	253	280		68	21	40	26	31	27	23	
54512	Mar. 28, 1921	286	♀ A4D-	66	156	181	211	229	247	263		90	25	30	18	18	16	23	
54513	Apr. 28, 1921	278	♂ E	70	149	176	202	219	233	250	274	79	27	26	17	14	17	24	4
54514	May 28, 1921	210	♀ A2D-	43	92	109	128	157	179	193	203	49	17	19	29	22	14	10	7
54515	June 25, 1921	275	♀ A2-4D-	49	120	155	189	201	219	241	256	71	35	34	12	18	22	15	19
54516	July 13, 1921	282	♀ A5D	81	136	159	180	198	217	240	259	55	23	21	18	19	23	19	23
54517	July 27, 1921	310	♂ C	69	150	175	208	232	250	270	291	81	25	33	24	18	20	21	19
54518	July 27, 1921	311	♂ E	51	134	182	216	244	262	278	296	83	48	34	28	18	16	18	15
54519	July 28, 1921	256	♂ E	72	120	166	179	205	228	238	248	48	46	13	26	23	10	10	8
54520	July 28, 1921	268	♀ D	67	119	168	188	206	232	245	263	52	49	20	18	26	13	18	5
54521	July 28, 1921	322	♂ C	62	182	199	217	247	271	287	309	120	17	18	30	24	16	22	13
54522	Aug. 3, 1921	287	♀ A3-4-5D+	66	126	149	166	185	204	232	270	60	23	17	19	19	28	38	17
54523	Aug. 3, 1921	339	♂ D	91	116	207	235	261	278	299	319	25	91	28	26	17	21	20	20
54524	Aug. 25, 1921	259	♀ D	51	111	142	175	195	217	232	246	60	31	33	20	22	15	14	13
54525	Sept. 11, 1921	220	♂ C	40	78	114	128	149	163	194	208	38	36	14	21	14	31	14	12
54526	Sept. 18, 1921	275	♀ A6D-	65	113	146	186	199	212	223	247	48	33	40	13	13	11	24	28
54527	Oct. 25, 1921	235	♂ C	71	110	137	168	177	191	214	225	39	27	31	9	14	23	11	10
54528	Dec. 20, 1921	329	♂ A	54	146	205	232	253	271	288	307	92	59	27	21	18	17	19	22
54529	Dec. 20, 1921	320	♀ B	67	131	174	191	213	236	273	295	64	43	17	22	23	37	22	25
54530	Jan. 3, 1922	317	♂ C or A	50	128	183	217	252	265	280	299	78	55	34	35	13	15	19	18
54531	Jan. 3, 1922	347	♀ B	84	154	193	232	256	278	305	332	70	39	39	24	22	27	27	15
	Length and increment averages of N. Y. Aq. whitefish.			67	132	165	191	213	233	253	271	65	33	26	22	20	20	18	
	Length and increment averages of 238 Lake Huron whitefish.			119?	213	268	322	366	412	449		94?	55	54	44	46	37		

*For explanations of the letters denoting the stage of sex organs, see p 403. Also see Table VII.

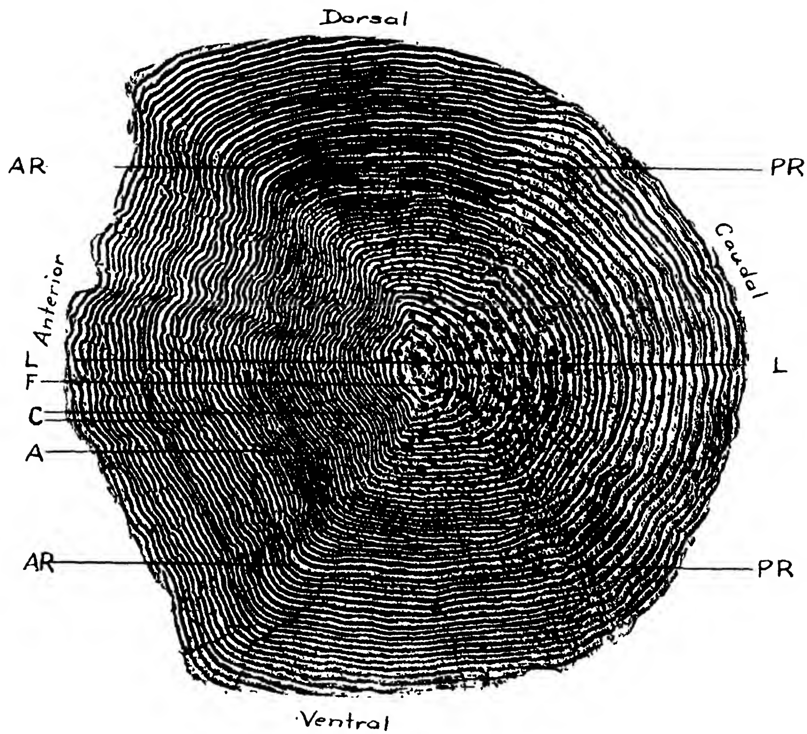


FIG. 137. Typical scale of Lake Huron Whitefish *(Coregonus clupeaformis* Mitchill) from East Tawas, Michigan. Length of fish, 197 mm., captured October 22, 1917. L-L, length of scale; F, focus; C, circuli; A, annulus of first winter; AR, antero-lateral ridges; PR, postero-lateral ridges; Dorsal, Ventral, Anterior, Caudal border and area. X-25.

FIG. 138. Scale of New York Aquarium Whitefish *(C. clupeaformis)* hatched January, 1913; killed December 1, 1920. U. of M. Museum No. 54507; Male, 265 mm. long, 7 years, 10 months old. Scale shows 7 completed annuli and a marginal growth. X-22.

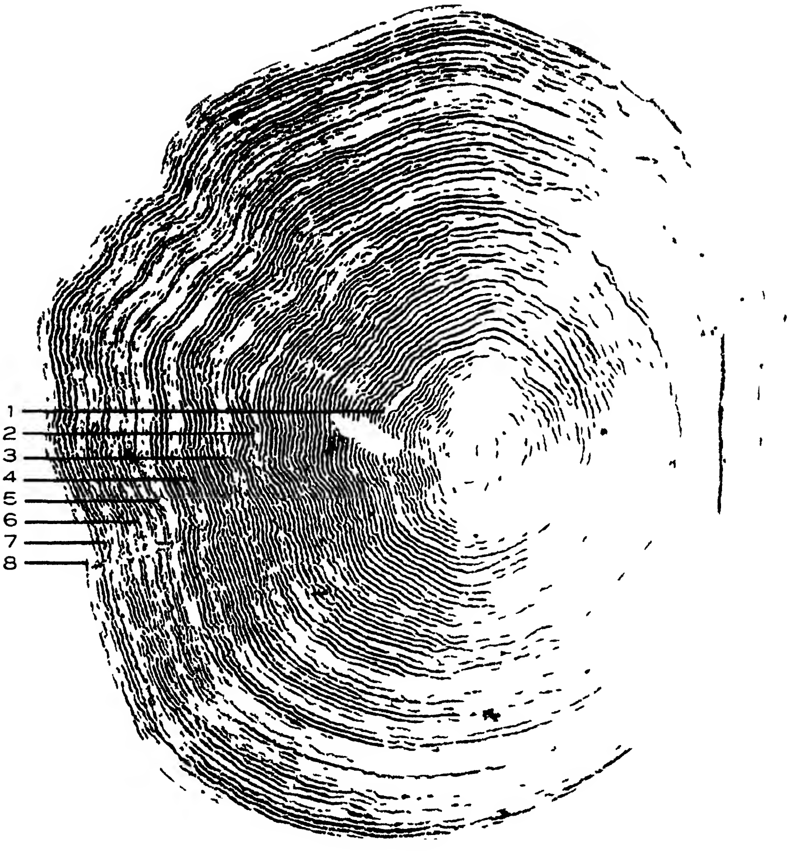


FIG 139 Scale of New York Aquarium Whitefish *(C. clupeaformis)* hatched January, 1913; killed April 28, 1921. U. of M. Museum No. 54513; Male, 278 mm long, 8 years, 3 months old. Scale shows 8 completed annuli, the eighth at the margin. X-18.

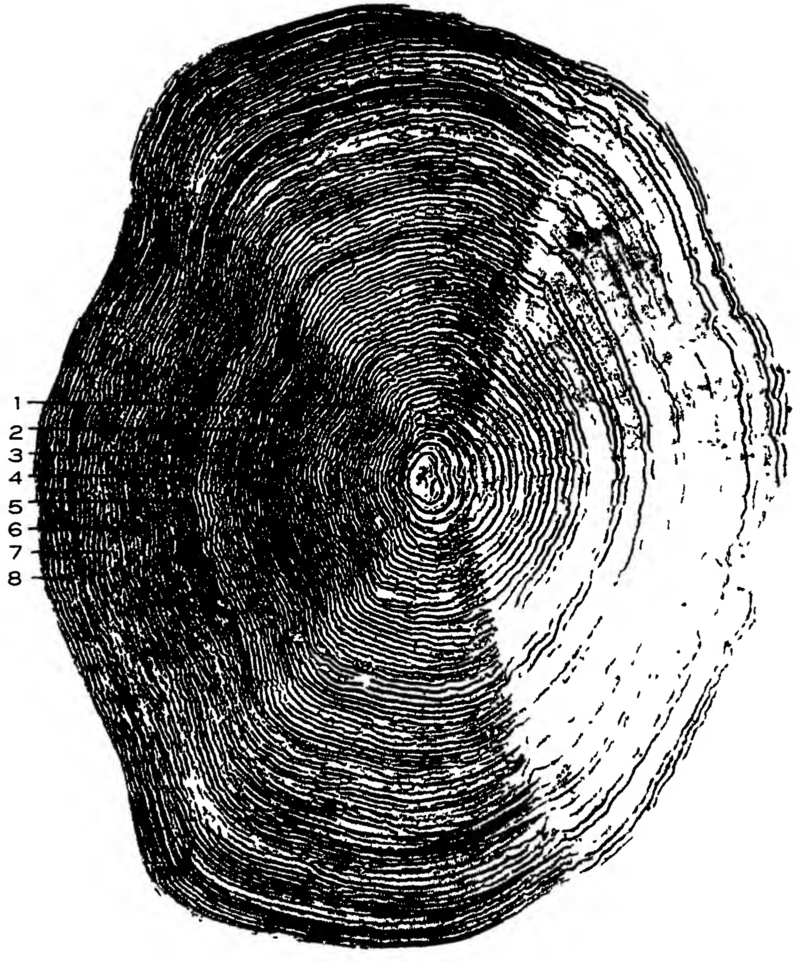


Fig. 140. Scale of New York Aquarium Whitefish *(C. clupeaformis)* hatched January, 1913; died July 13, 1921. U. of M. Museum, No. 54516; Female, 282 mm. long, 8 years, 5½ months old. Scale shows 8 completed annuli and a marginal growth. X-18.

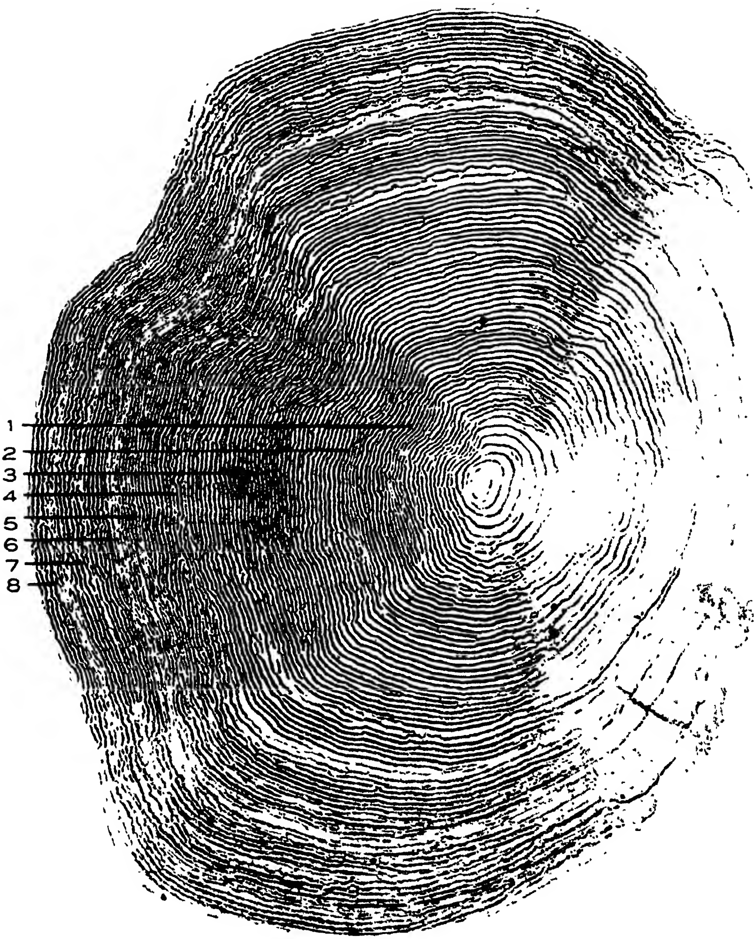


FIG. 141. Scale of New York Aquarium Whitefish *(C. clupeaformis)* hatched January, 1913; died August 3, 1921. U. of M. Museum No. 54523; Male, 339 mm. long, 8 years, 6 months old. Scale shows 8 completed annuli and a marginal growth. X-16.

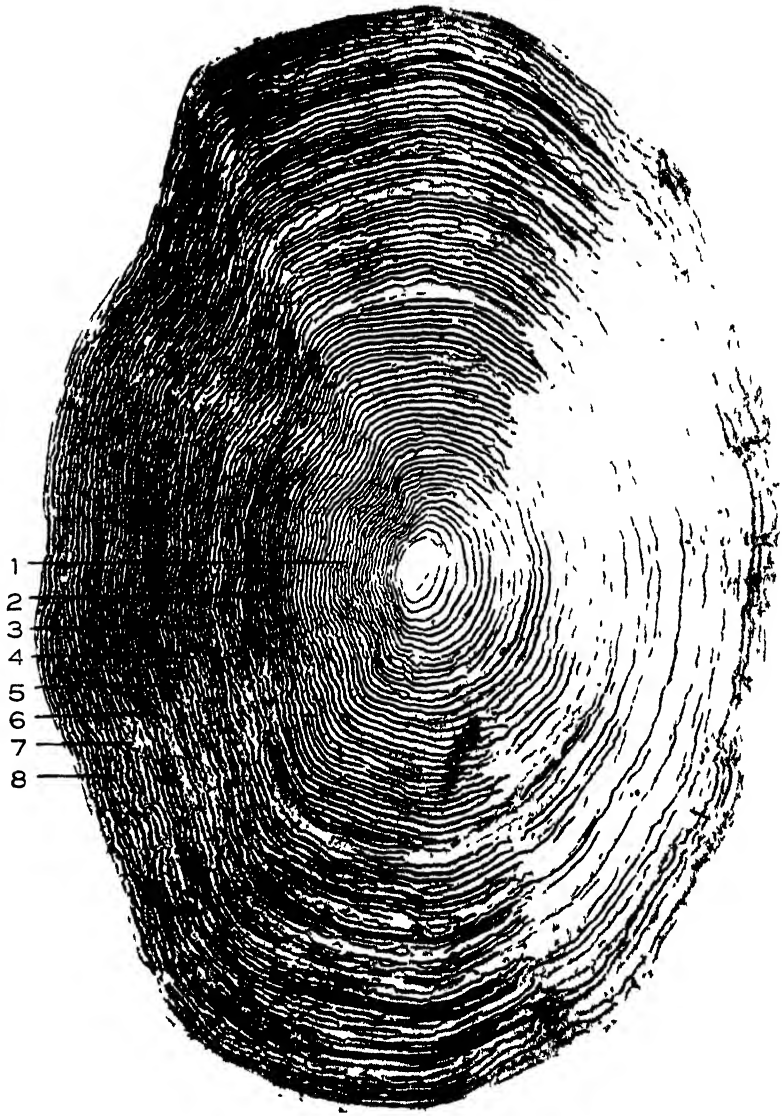


FIG. 142. Scale of New York Aquarium Whitefish *(C. clupeaformis)* hatched January, 1913; died January 3, 1922. U. of M. Museum No. 54531; Female, 347 mm. long, 9 years old. Scale shows 8 completed annuli and a marginal growth. X-19.

Figs. 138-142 are photomicrographs of scales taken from Aquarium fish killed at different ages. On each photograph reference lines have been drawn which indicate the positions of the annuli of the different years. On comparing the scales of these aquarium whitefishes with those of the wild whitefish, it may be seen that the former are much stunted in growth; their circuli are more irregular and crowded together, while their annuli, in some instances, nearly come into contact in the posterior or exposed area of the scale. In some scales the annuli are difficult to observe, but by the use of various magnifications and by the manipulation of the light source they can be determined. In most of the fish several scales are necessary for an age-determination. I gradually discovered, however, that those aquarium scales whose caudal area is longer than its anterior area and whose form approaches the elliptical possess annuli that can be more readily determined than those of scales without these characters. Such scales were usually obtained from the area between the pectoral fin and the lateral line. Those photographed and employed in this study were taken from the left side of the body.

The first specimen died August 13, 1920, at the age of seven years and seven months. Its scales possessed seven annuli with a small amount of marginal growth. The number of annuli, thus, corresponded with the number of years of life of the individual. The next seven specimens received (54506 to 54512, Table I), which ranged from seven years and nine months to eight years and two months in age, also possessed scales with seven completed annuli and various amounts of marginal growth. Fig. 138 represents a photograph of a scale from the specimen killed December 1, 1920, and shows seven annuli with the eighth year increment at the margin. The eighth annulus is completed in April. Fig. 139, a photograph of a scale from the April specimen, shows the eighth annulus situated at the margin. In the remaining eighteen specimens (54514 to 54531, Table I), which ranged from eight years and four months to nine years in age, the eighth annulus is entirely removed from the margin and surrounded with various amounts of the ninth year increment. Figures 140, 141 and 142 are photographs of scales from specimens that died July 13, 1921, August 3, 1921, and January 3, 1922, respectively. Each figure shows eight annuli and, presumably, a completed ninth year's growth.

It thus appears (1) that the specimens received from August, 1920, to March, 1921, which represent ages from seven years and seven months to eight years and two months possessed

Table II—Showing at different dates the average total length in mm. of magnified scales of individuals of whitefish reared in the New York Aquarium; the percentage of the scale length outside the outermost annulus (marginal growth) in the antero-posterior diameter included in the last annulus, the part of this marginal growth percentage formed since the preceding date and the number of scales upon which the averages are based.

U. of M. Museum Number	Name of Fish	Date of Removal of Scale	Date of Death of Fish	V7 or V8 Average Length of Scales at End of 7th or 8th Growth Year	v8 or v9 Average Length of Marginal Growth in 8th or 9th Year	v8/V7 or v9/V8 Percentage Added to Scale Outside Last Annulus	Δ Percentage Added Since Preceding Date	Number of Scales on Which Each Average is Based
54507	Crooked-back	Oct. 26, 1920		201	5.8	2.8*	+2.8*	4
		Nov. 26, 1920		167	3.7	2.2	—0.6	3
		Dec. 1, 1920	Dec. 1, 1920	175	5.2	2.9	+0.7	5
54516	Double-crook	Dec. 30, 1920		185	16	8.6*	+8.6*	1
		Feb. 25, 1921		183	16.5	9.0	+0.4	2
		April 26, 1921		220	5	2.2z	+2.2z	2
		June 29, 1921		221	16	7.2	+5.0	3
		July 13, 1921	July 13, 1921	189	14	7.4	+0.2	4
54515	Open-gill	Jan. 26, 1921		175	12.5	7.1*	+7.1*	2
		March 26, 1921		199	13.3	6.7	—0.4	3
		May 26, 1921		221	15.6	7.0z	+7.0z	3
		June 25, 1921	June 25, 1921	183	16.6	9.0	+2.0	6

* Since March or April, 1920.

z 1921 growth.

scales with seven annuli and various amounts of marginal growth and therefore belong to the same growth year, the eighth, even though the three fish received from February to March actually were in their ninth year of life; (2) that those received from April, 1921, to January, 1922, which vary from eight years and four months to nine years in age possessed scales with eight annuli and different amounts of marginal growth.

The annuli are thus actually proved to be of the same number as that of the winters of the fish's life, if we exclude the first one in which the fish was hatched.

Marginal Growth and Time of Formation of Annuli

Two specimens of the aquarium fish were segregated in the New York Aquarium and kept living with the purpose of taking scales from them at monthly intervals in order to follow the seasonal changes in the scales from November until June. Owing to deaths a total of six fish was employed during this interim, three of which lived for periods of two, six and seven months. In Table II these fish are designated by names indicating slight physical peculiarities and by their museum numbers. The names should not be taken as indicating that the fish were notably deformed. They were the smaller, poorer fish, less desirable for exhibition purposes. Table II shows the average total length in mm. of the magnified scales taken from these fish in different months, the average total length in mm. of the marginal growth, the percentage of its length in the antero-posterior diameter of that part of the scale included in the last annulus, the difference in the percentages of successive months and the number of scales upon which each average is based. The percentages in this table are, however, only approximately correct as they vary with the areas on the body of the fish as well as with the scales taken from the same area. However, as all the scales, except those removed from the dead fish, have been taken from the same area, the variability of the scale values has been reduced to a minimum so that they may be used with confidence in drawing certain conclusions.

The discrepancy in the fall or winter percentages (which seem to show scale absorption) of Crooked-back and Open-gill are presumably due, then, to the variability of their scales. The small difference (+0.4) between the two winter percentages (8.6 and 9.0) of Double-crook which represent a period of two months, likewise may be looked upon as due to this same variability and thus can have no significance. Presumably, then, the percentages in column v8/V7 or v9/V8 remain constant for

Table III—Showing for all New York Aquarium fish of Table I the percentage of the scale increment of the 7th, 8th and 9th year in the total scale length of the 6th, 7th and 8th year respectively and the average for each series of percentages.

Date of Death	v7/V6 Percentage of 7th Year Increment in Scale Length of 6th Year	v8/V7 Percentage of 8th Year Increment in Scale Length of 7th Year	v8/V7 or v9/V8 Percentage of Incompleted 8th or 9th Year Increment in Scale Length of 7th or 8th Year respectively	Number of Scales on Which Percentages Are Based
August 13, 1920	14.5		4.7	2
October 26, 1920	8.2		4.1	2
December 1, 1920	9.8		2.9	5
December 30, 1920	7.4		4.7	2
January 28, 1921	8.8		6.2	2
February 28, 1921	5.2		6.4	2
March 4, 1921	10.9		8.5	2
March 28, 1921	6.6		8.9	2
			5.8a	
April 28, 1921	7.3	9.3	1.6b	1
May 28, 1921	8.1	5.0	3.4	1
June 25, 1921	9.8	6.5	9.0	1
July 13, 1921	10.8	7.6	7.4	1
July 27, 1921	8.9	7.8	6.5	2
July 27, 1921	5.9	6.5	5.2	1
July 28, 1921	4.5	4.3	3.0	1
July 28, 1921	5.6	7.4	2.0	1
July 28, 1921	5.9	7.5	4.3	1
August 3, 1921	13.4	16.3	6.1	1
August 3, 1921	7.3	6.8	5.6	1
August 25, 1921	7.1	5.7	5.4	1
September 11, 1921	18.8	7.3	5.7	1
September 18, 1921	5.2	10.8	11.5	1
October 25, 1921	12.0	4.9	4.6	1
December 20, 1921	6.3	6.8	7.1	1
December 20, 1921	15.8	8.2	8.4	1
January 3, 1922	5.9	6.5	6.1	1
January 3, 1922	9.8	8.9	4.5	1
Average =	8.9	7.6	6.5c	

a—Average for incompleted 8th year, August to March. b—Ninth year increment begins.
c—Average for incompleted 9th year, August to January.

each fish during the fall and winter, *i. e.*, the marginal growth of the scales is arrested during the period from October to March. Marginal growth is resumed sometime in April (or March?). On April 26, 1921, the new marginal growth of Double-crook showed a percentage of 2.2, which value was increased to 7.4% on July 13, two and one-half months later. Similarly, Open-gill showed a new marginal growth of 7.0% on May 26, 1921, which percentage was increased to about 9.0 on June 25, one month later. The percentages of Double-crook and Open-gill are thus entirely consistent with and comparable to each other from April on and show that rapid scale growth is resumed sometime in April (or March?) and is continued at least until July.

In order to show approximately by comparison how much of the new year's growth was completed by Double-crook and Open-gill at the time of death, I computed percentages, similar to those of Table II for the preserved specimens listed in Table I. Table III shows in column v7/V6 the percentage of the scale increment of the seventh year in the total length of the scale included in the sixth annulus, in column v8/V7 the percentage of the scale increment of the eighth year in the total scale length included in the seventh annulus, and in column v8/V7 or v9/V8 the percentage of the incomplete marginal growth of the eighth or ninth year in the total scale length included in the last completed annulus (7th. or 8th.). The average for each series is given at the bottom of each column.

From this table it may be seen that the average percentage of the completed seventh year scale increment in the total scale length of the sixth year for 27 specimens is 8.9 and somewhat less, as is to be expected, for a similar percentage for the next year (7.6) for 19 fish. When these averages (8.9 and 7.6), which represent the completed seventh and eighth growth years are compared with the percentages of Double-crook and Open-gill (7.4 and 9.0) and when it is remembered that the percentage for the ninth year may reasonably be expected to be somewhat less than that for the eighth, it may safely be assumed that the scales of the segregated fish have just about completed their ninth year's growth and certainly would have done so by August or September.

If we now assume that August closes the period of scale growth and compute the average of the percentages of the incomplete ninth year from August to January and compare this average with those of the two preceding completed years and

with the percentages of the two segregated fish we may obtain a criterion which ascertains roughly the probability of the correctness of our assumption relative to the time of the cessation of scale growth. Table III shows that such a ninth year average is 6.5%, which compares favorably with those of the two preceding completed years (8.9 and 7.6), and may therefore be considered as representing the average of a completed ninth year. The ninth year average (6.5) thus suggests the completion of scale growth by August not only in the fish of Table II (with 9th year percentages of 7.4 and 9.0), but also in those of Table I. Again, when the average of the percentages of the incomplete eighth year from August to March is compared with that of the completed eighth year, it is found that the former (5.8) compares fairly well with the latter (7.6) when it is remembered that the fish sacrificed first (included in the 5.8 average) were the poorer and less valuable specimens. Thus again scale growth may presumably be considered complete by August. Also, Tables II and III show that the percentages of the incomplete eighth and ninth years show no consistent increase from August and October to April, while those of the ninth year from April to June or July do.

In the light of the preceding discussion it now appears reasonable to accept the interpretation presented on page 391 relative to the constancy of the fall and winter percentages given in Table II.

Table III, column v8/V7 or v9/V8, further corroborates Table II and shows that marginal growth is resumed in April. All the fish killed after April, 1921, completed the new annulus and showed various amounts of new marginal growth on their scales.

The percentages of Table II show, then, (1) that there was no marginal growth present in November and December of 1920, and in January, February and March(?) of 1921, and, (2) that a new annulus was recognizable in April, 1921, and was correlated with a resumption in scale growth. The percentages of Table III corroborate the conclusions based on Table II, and in addition show in conjunction with Table II that marginal growth was presumably arrested by August in 1920 and 1921, and certainly by September. The data of both tables (II and III) therefore prove that the annulus is a winter-mark due to a retardation or cessation of scale growth and is completed upon the resumption of rapid scale growth in the spring of the year.

Table IV—Showing for 76 Alpena whitefishes collected September, 1917, the relation of the average length of the diameter (v), anterior (ac) and posterior (pc) radius of the scale to the average body length (K), all lengths expressed in mm., for fish in years III to VII inclusive.*

In Year	III	IV	V	VII
K	269 (47)	315 (14)	352 (9)	456 (6)
v	5.75 (47)	6.75 (14)	7.49 (9)	9.58 (6)
ac	3.19 (47)	3.86 (14)	4.34 (9)	5.80 (6)
pc	2.56 (47)	2.89 (14)	3.15 (9)	3.78 (6)
K/v	46.78	46.67	46.99	47.60
K/ac	84.33	81.61	81.11	78.62
K/pc	105.08	108.99	111.75	120.63

*Numbers in parentheses following averages indicate the number of specimens employed, the sixth age-group contains only one specimen, therefore, omitted

Correlation Between Annual Growth in Length of Body and Scales

It now remains to examine for the whitefish the correlation between the annual increment in length (or other dimension) of scales and length of body. Had it been possible to measure the body lengths of the living aquarium whitefish accurately at the time of the removal of their scales, this correlation could have been established by direct observation. Obviously, Table I does not afford material for this purpose as the number of specimens received each month is too small to warrant valid averages of monthly growth increments in body and scales. The available aquarium whitefish therefore cannot show the proportionate growth of body and scale.

Wild whitefishes may be used to show this correlation. In this case it is necessary that a large amount of strictly homogeneous material be used, *i. e.*, the fish of the several age-groups must all belong to the same race and have similar rates of annual growth increments, and only scales from corresponding body areas must be employed. These requisites necessitate the acquisition of a large collection of fish taken at the same time and at the same locality. At present no such whitefish material is available. There are, however, at hand, series of body and scale length measurements of a small collection (76 fish) of Lake Huron whitefishes taken September, 1917, at Alpena, Mich. A summary of their data is given in Table IV.

In row K, Table IV, is shown the average length in mm. of the fish of each age-group, the age-group referring to the year of life in which the fish were captured. The number of specimens in each age-group is shown in parenthesis. In row (v) is given the average length in mm. of the scale diameters of the fish of each age-group. In rows (ac) and (pc) the same averages are

Table V—Showing for each year for Alpena whitefish (Table IV) in the seventh year the average length in mm. calculated from the diameter (v), anterior (ac) and posterior (pc) radius of scales (Table IV), and the difference between the calculated averages and those of the age-groups obtained from actual measurements (K).

	III	IV	V	VII
K	269	315	352	456
Calculated (K) from (v)	274	321	357	
Calculated (K) from (ac)	251	303	341	
Calculated (K) from (pc)	309	349	380	
Difference (K) & (K from v)	+5	+6	+5	
Difference (K) & (K from ac)	—18	—12	—11	
Difference (K) & (K from pc)	+40	+34	+28	

given for the anterior and posterior radius of the scale respectively. In the last three rows are shown the body-scale ratios for each age-group based on the diameter (v), anterior (ac) and posterior (pc) radius respectively.

The number of fish in each age-group is not as large as one could wish, but may be sufficiently large to show roughly the relation of the length of the various scale dimensions to body length. It may then be seen that the K/v ratio is about the same for the third and fourth age-group and rises slightly in the fifth and again in the seventh. This means that the diameter increases in length in a simple proportion to the increase in the length of the body during the fourth year and increases at a slightly slower rate relative to the body in the fifth and seventh years and presumably also in the sixth for which no values can be given. The K/ac ratio is found to decrease with age, while the K/pc ratio increases with age. This means that the anterior radius of the scale grows faster relatively than the body with age, whereas the posterior radius grows more slowly with age. None of the measured scale dimensions therefore grow strictly proportionate to the body.

In order to show roughly in a practical way which dimension most nearly acquires this proportionate growth and furnishes the most accurate estimated length values, I calculated the average length for each year of the fish in the seventh year, using the average scale dimensions of Table IV. The estimated lengths are shown in Table V. From this table it may be seen that there is a high degree of correspondence between the lengths calculated from the diameter and the actual lengths, and that the

former are somewhat higher than the latter. The lengths calculated from the anterior radius are lower, while those calculated from the posterior radius are much higher than the actual lengths. It is, however, realized that these calculated and actual values may not be strictly comparable as the two series of values represent different year-classes which may have varied considerably in their rate of growth. Strictly, series of fish of the same year-class collected in the same season of different years and at the same locality are required for an absolutely valid check on calculated values.

Table V also shows that the calculated values from diameters are consistently found between those based on the radii. This was also found to be true for the individual fish. Experience has shown that in practically every species of fish whose scales were studied the calculated values based on radii (no other dimension is ever used) and checked with the actual values were always found to be too low for the early years of life. The Coregonines prove to be no exception. In the light of past experience therefore, and in view of the fact that diameter measurements of whitefish scales raise the calculated values, especially those for the earlier years, above those based on the anterior radius, it may be deemed advisable to test the various dimensions of the scales, where possible, before undertaking any extensive scale work for a species.

Tables IV and V show for the whitefish (1) that the diameter, anterior and posterior radius of scales increase in length at very different rates with respect to the rate of increase in the length of the body and that consequently the calculated length values based on the different scale dimensions vary significantly, (2) that none of the three scale dimensions considered increase in length at a rate strictly proportionate to the rate of increase in length of the fish, (3) that, presumably, the diameter of the scale increases in length at a rate more nearly proportionate to the rate of increase in body length than either the anterior or posterior radius and therefore should be used for the calculations of length values, and (4) that the calculated values based on the diameter always lie between those based on the anterior and posterior radii.

Life History of the Aquarium Whitefish and the Factors of Annuli Formation

In view of the great diversity of opinion among investigators, and in view of the disagreement and contradiction of the conclusions reached by various authors from laboratory experi-

ments and field observations relative to the factors responsible for the formation of annuli, it was deemed advisable to obtain as complete a life history as possible of the New York Aquarium whitefishes and thus, perhaps, determine to a certain degree the relative significance of each environmental factor in the formation of annuli. It is realized that these life history data are not equivalent to those of carefully planned and executed series of experiments in which only one factor of the environment is altered at one time and the results checked with those of a control. Yet, it will be seen that experimental requirements are partly fulfilled for the fish were regularly supplied with food in amounts controlled by their appetites, while the temperatures varied from those of summer to those of winter and vice versa. And as the period of rapid scale growth and the time of the formation of an annulus are known the effect upon the scales of a change in a factor may be approximately ascertained. I am indebted to Miss Mellen and to Mr. Robert J. Lanier, who reared the whitefishes, for most of the life history data. I alone am responsible for the conclusions derived from them.

It has now been proved (p. 394) that the formation and completion of an annulus is dependent upon the retardation or cessation and resumption of scale growth, and that scale and body growth are closely correlated; therefore, any factor that can affect the growth rate of the body may have primary significance in the formation of an annulus. But to hold such a factor responsible it must be established that a change in this factor occurred previous to or synchronously with the change in the rate of growth and that no resumption of rapid scale or body growth can occur until the change in the factor is reversed or its effectiveness lost. The primary factors may be different from year to year or even from season to season in the same year.

(a) Food

The Aquarium whitefish were fed in about the same way throughout the year. Miss Mellen writes: "I have consulted our superintendent (Mr. Robert J. Lanier), who reared the whitefishes born in 1913, as to their food since hatching, and find that in early infancy they had the advantage of some live food, receiving first herring roe, next a few mosquito larvae, third, the fry of pike perch, which happened to be hatching at just the right time, although all would not take this food, as, unlike most fishes, they do not normally eat their own kind, and lastly, minced beef-heart. Feedings were very frequent during the first couple of years, after which they were fed daily on beef-heart. From 1915 to 1918 inclusive they were fed exclusively on beef-heart three times a week; and it is only since 1919 that they

have been fed with beef-heart exclusively three times a week in summer and beef-heart once, clam twice a week in winter."

The amount of food, however, actually consumed by the fish varied somewhat with the seasons. In the earlier years when the fish were fed daily, Mr. Lanier gave them less food during January, February and March in spite of the fact that they were always ready to eat. During their third year an apparent change in their appetites occurred, so that thereafter they were fed only three times a week. Since this year (1915) it was also noticed that the fish "did not eat quite as much during January, February and March," though the number of feedings remained constant throughout the year.

It is obvious that since the character of the food and the number of feedings remained constant summer and winter for several consecutive years these factors could not have altered the rate of scale or body growth. The amount of food, however, offered or taken by the fish, did vary with the season. How much the amounts varied is not known. In the fall of 1920 this change in the amount of food could not have had any significance inasmuch as scale growth was arrested before January, 1921, when this factor was first altered. In April, 1921, the rations were increased for the same reasons that they were decreased in January, viz.—a change in the appetites of the fish. It was previously shown that scale growth was resumed in March (?) or April (p. 393). It thus appears that food and growth are correlated in April, 1921, but in this case the former is presumably only of secondary importance. As nothing definite is known about the distribution of growth in the other years of life of these fish, the relative significance of food as a factor in these years can only be conjectured and therefore requires no discussion here.

(b) Temperature

Table VI shows the monthly and yearly mean temperatures in degrees, Fahrenheit, of the fresh water entering the New York Aquarium, from 1913 to 1920, inclusive. As soon as the water reached a temperature of about 60°F (15.6°C) in the summer, it was refrigerated and maintained at a temperature which varied from 54° to 57°F and averaged about 55°F (12.8°C), except during the summer of 1921, when the range was changed to 50° and 54°F, and the average reduced to about 52°F (11.1°C). The months in which the refrigerating plant was started and stopped are indicated by the letters r and s respectively in Table VI. In Fig. 143 are plotted a curve (T) based on the average monthly temperatures of Table VI and growth curves of the scales of Double-crook (D) and Open-gill (O)

Table VI—Record in degrees, Fahrenheit, of Monthly and Yearly Mean Temperatures of Fresh Water Entering the New York Aquarium, from 1913 to 1920, inclusive.[a]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Averages
1913	43	41	42	50		r	67	71	70	65	56s	48	55
1914	41	38	40	45	53r	60	67	71	70	65s	54	43	54
1915	39	38	40	47	53r	59	65	69	70	63	54s	42	53
1916	38	37	36	43	52r	56	64	69	69	63	55s	45	52
1917	37	36	39	44	50	57r	62	65	64	58s	49	39	50
1918	35	37	39	44	55	56	58r	64	66	59s	52	42	51
1919	39	38	40	45	54r	60	64	67	66	63	54s	43	53
1920	37	37	39	43	51	61r	66	68	67	63	54s	45	53
Monthly Averages	39	38	39	45	53	58	64	68	68	62	54	43	53

a—From daily observations made by Mr. W J DeNyse.

r—Refrigerating plant started.

s—Plant stopped, the temperatures do not represent those of the refrigerated water The temperatures of the refrigerated water averaged about 55° F every summer, except that of 1921 when it averaged 52° F.

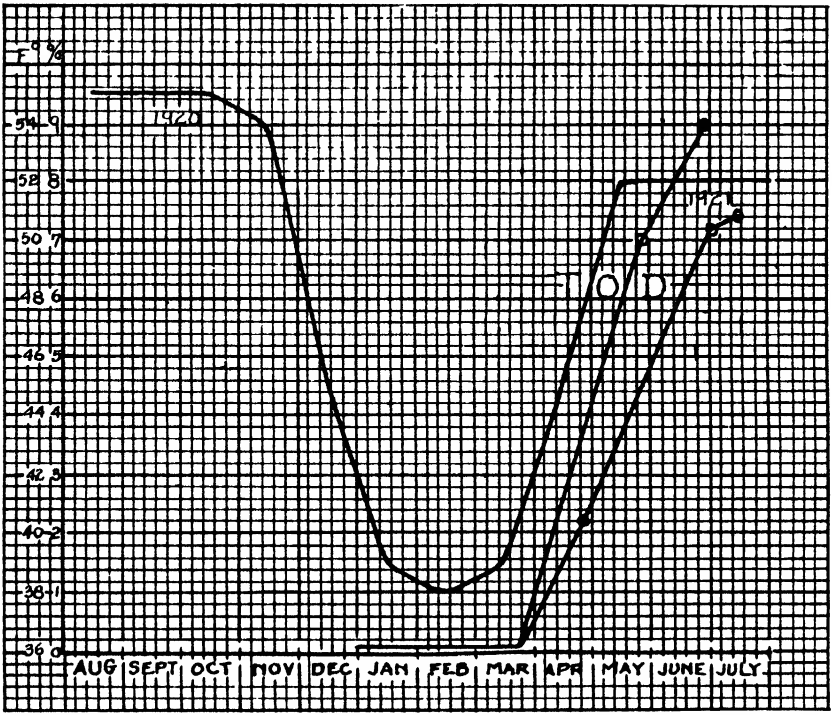


FIG. 143. Showing the relation between the rate of growth of the scales of Open-gill (O) and Double-crook (D) and the temperature (T) of the aquarium water. T-curve based on the average monthly temperatures of the refrigerated and non-refrigerated water shown in Table VI. O-curve based on the percentages of Table II, which represent the total scale growth of Open-gill from March, 1921, to June, 1921. D-curve based on the percentages of Table II, which represent the total scale growth of Double-crook from March, 1921, to July, 1921.

based on the percentages of Table II, which represent the renewed growth of the scale after March, 1921. The growth curves are only approximately correct as the scales of each fish were taken in alternate months.

Fig. 143 shows that the curves of scale growth adhere very closely to the curve of temperature. No growth occurred during the period of low temperatures in January, February and March, and the greatest increase in growth took place at the time of the greatest rise in temperature in April and May. The maximum temperatures were reached in May when the water was refrigerated and maintained throughout the summer at an average constant temperature of about 52°F. Scale growth, however, continued, at least in Open-gill, throughout June. Scale

growth therefore was not arrested by the temperatures of the refrigerated water. As these temperatures do not represent those of the water in the whitefish tanks, they may be a little too low, especially those of the non-refrigerated water. This, however, would not alter the general appearance of the temperature curve nor the conclusions based on it.

It is thus seen that scale growth and the temperature of the water are correlated in the spring of 1921, the latter presumably having primary significance. That a low temperature is here a primary factor in growth seems corroborated by the fact that a decrease in the amount of food consumed occurred synchronously with a decrease in temperature and an increase in food consumption with an increase in temperature. The effect of low temperatures upon the metabolism of the body is well stated by Dr. Fulton (1904), who writes (p. 170): "Temperature is active in modifying the rate of growth by acting directly upon the metabolism of the fish and also by affecting the rapidity of digestion. In very cold water the fishes give up feeding altogether, because the ferments upon which digestion depends do not act, or act very slowly, at low temperatures, and in fishes, as in other animals, appetite waits on digestion, and this is, on the other hand, correlated with the metabolism in the tissues. It has been shown by Krukenberg that the pepsine or analogous body in the stomach of fish acts as well at 20°C as at 40°C, at which, among mammals, digestion is most active, and that the rapidity of its action is closely related to temperature; and Knauthe and Zuntz have shown that the same thing applies to the metabolism in fish, the vital activities being more active in the higher temperature, as shown by the excretion of carbonic-acid gas and other products of metabolism."

But, as both food and temperature remained practically constant during the summer until November, what factor must then be held responsible for the arrest in scale growth in August or September? As the aquarium water is well aerated its gaseous content cannot be held responsible; nor could any probable changes in its mineral or salt content account for the decrease in growth. The only remaining variable is sexual maturity.

(c) Sexual Maturity and Spawning

Before attempting to describe the conditions of the ovaries and testes of the various New York Aquarium whitefishes at the time of death, it seems advisable to describe first the normal natural conditions of the sex organs as found in wild whitefishes of various ages. The following description is based on many specimens of Lake Huron whitefishes.

In order to determine the sex of immature wild whitefishes the sex organs must be closely scrutinized often with the aid of

a magnifying lens or microscope. This difficulty of determination is due to the fact that the ovaries and testes are quite similar in appearance in the very young whitefishes. Both consist of narrow, thin, flat strands of soft, whitish material and extend from the anterior to the posterior end of the body cavity along its dorsal wall. In the larger immature fish the two kinds of sex organs can be distinguished by their structure. When an ovary is picked up and stretched transverse folds or layers become evident, while the testis under like treatment appears to be a compact homogeneous structure. In still older fish color may also be critical; the ovary becomes yellowish, while the testis retains its whitish color.

In a maturing female the ovary gradually increases in size, the enlargement beginning at the anterior end of the body cavity. Minute round yellowish eggs appear in the ovary folds. At the time of spawning the ovaries have usually enlarged to such extent as to distend and fill the entire body cavity. The condition of the ovary and the size of the eggs thus indicate the stage of sexual maturity in the female. A ripe egg is about 3 mm. in diameter. The maturing testis also increases in size, the enlargement commencing at the anterior end of the body cavity. As the testes grow they extend further into the abdominal cavity and increase in width and thickness. At the time of spawning they nearly fill the body cavity, but usually do not distend it, as do the ovaries. The size of the testes is then a rough index to sexual maturity in the male. When the eggs and sperm are ripe they are easily pressed out of the body. The sex organs of a spent fish are soft and flaccid. This condition is more easily determined for females than for males, and even among the former doubtful cases arise, the magnitude of the doubt depending partly, I presume, upon the length of the interim between the spawning and the date of the capture of the fish.

In describing the various conditions of the sex organs of the New York Aquarium whitefishes I devised a number of phases, each phase indicating rather definite conditions. As the individuals represent nearly every month of the year the conditions of their sex organs intergrade more or less imperceptibly, and it is therefore impossible always to refer a specimen to one phase; parts of different phases may be found in one individual. The ovaries alone permit of a rather definite classification and they only must be considered reliable in a discussion.

The various stages of development[3] are considered under five principal phases designated by the letters A, B, C, D and E as follows:

[3]These descriptions are based on the sex organs of the Aquarium fish preserved in 5% formalin and later transferred to 70% ethyl alcohol.

E: ♀—anterior ¼ of ovary enlarged; eggs microscopic or very small in size.
♂—anterior ¼ of testis enlarged into a flat, white gland; remainder transparent.

D: ♀—anterior ½ of ovary enlarged; ovary flat, rigid, ¾ in. at its widest; eggs of year are round, whitish, easily visible to naked eye, 1 mm. or less in diameter.
♂—anterior ½ of testis enlarged; compact gland thicker and wider than in (E), about ¼ in. at its widest.

C: ♀—entire ovary enlarged; eggs 1-2 mm. in diameter.
♂—anterior ¾ and posterior end of testis enlarged, ½ in. at its widest.

B: ♀—compact ovaries fill body cavity; yellowish eggs nearly ripe, 2-3 mm. in diameter; fish about ready to spawn; body may be pearled.
♂—hard testes fill body cavity; fish about ready to spawn; body may be pearled.

A: ♀—matured eggs retained and in process of absorption. Coincident with this condition is that of (E) or (D), *i. e.*, eggs of the year are evident. Ovaries may be soft, flaccid; retained eggs found either in ovary, in body cavity or in both; eggs average 3 mm. in diameter when round and smooth; eggs are found in various conditions, several of which may be found in one individual; these conditions are designated by number under (A):

1. Eggs hard, round, smooth; each egg partly turned a brownish yellow.
2. Eggs wrinkled, indented, of brownish yellow color; float in water.
3. Eggs wrinkled, indented, peripheral portion of each egg of a dull or dirty transparency; float in water.
4. Eggs flattened, crushed, sometimes a little brown color left; contents absorbed.
5. Eggs with dark reddish color, and a solid, glassy appearance; filled with minute oil globules; eggs about 1 mm. in diameter and scattered among the eggs of the year in a soft ovary; glassy eggs show no evidence of absorption.
6. Ovary soft, flaccid with many eggs of the year, but no retained eggs evident.

♂—testes smaller than in (B); flabby, *i. e.*, fish spent, or testes compact, of reddish color with sex products seemingly retained and undergoing absorption; body may be pearled.

Table VII—Showing distribution in time of the phases of sexual development in the Aquarium whitefish. For explanation of letters and numbers see page 403. Also see Table I.

Month	Females	Males
November	None	None
December	B (20), peduncle pearled; A1-2-4E (30) numerous retained eggs in ovary and body cavity	D (1); A (20) body heavily pearled, testes reddish
January	B (3), abdomen distended; A1-2-3D-(28) retained eggs numerous, mostly in body cavity	C or A (3)
February	None	None
March	A3D-(4) retained eggs numerous, in body cavity; A4D-(28) ½ doz. flattened eggs in body cavity	None
April	None	E (28)
May	A2D-(28) retained eggs numerous, in body cavity	None
June	A2-4D-(25) few wrinkled eggs in ovaries and few partly absorbed ones among pyloric coeca	None
July	D (28); A5D (13) ovary soft, no wrinkled eggs	E (27, 28); C (27, 28)
August	D (25); A3-4-5D + (3) retained eggs numerous, in ovaries and body cavity	D (3, 13)
September	A6D-(18) ovaries flaccid, no retained eggs	C (11)
October	None	D (26); C (25)

The distribution of these phases in time among the aquarium whitefishes is indicated in Table VII. The number in parenthesis following each phase refers to the day of the month on which the specimen died. Each such number represents one individual. The minus or plus sign following a letter indicates an early or a late phase respectively. Two or more phases in one individual are designated by a combination of the proper letters. The phase of each specimen is also shown in Table I.

Table VII shows (1) that no immature female whitefish were received, (2) that two females were ready to spawn in December and January, (3) that retained eggs were present from December to August (no females were received in February, April, October and November), but that after January all the retained eggs, the glassy ones excepted, were undergoing absorption or disintegration, (4) that the eggs of the year, whether found with the retained eggs or not, were in the same phase of development from January to September, those of fish received July and later being a little more advanced than those of females received before July, and (5) that the ovaries of the specimens that died July 13 and September 18 were soft, but did not contain wrinkled eggs.

From these facts we conclude, (1) that the Aquarium whitefish were sexually mature in both their eighth and ninth years, (2) that in most fish spawning conditions were present in December and January and thus that the sex products of the Aquarium whitefish ripen later in the season than those of the wild whitefishes which usually spawn sometime in November and (or) early December, and (3) that the majority of the Aquarium whitefish do not spawn, but retain their eggs in the ovaries or in the body cavity where they undergo a process of absorption or disintegration. From the condition of the eggs of the year and of those undergoing disintegration in different months, it appears highly probable that the phase of rapid growth is initiated in the eggs sometime after September and completed sometime before March or February (?). The conclusion that the aquarium whitefish do not spawn agrees with the statements of Mr. Lanier to the effect that no spawning was ever observed among these fish. It may also be observed here that sexual maturity is not correlated with the size of the whitefish, but rather with its age. Thus, for instance, in Table I the eight and nine-year-old females of January 28 and May 28, which measure 219 mm. and 210 mm. respectively, are no larger than a two-year-old whitefish from Lake Huron; yet, no two-year-old whitefish has ever been known to spawn.

That sexual maturity can be a factor in the formation of annuli becomes evident when it is recalled that many species of

fish, especially the salmon to which the whitefish are related, practically cease growing when developing a spawning condition, even though the amount of food ingested remains practically constant. It is also a fairly well established fact for many species that the annual increments in body growth of the young fishes are very noticeably reduced in that year when sexual maturity first occurs. Since it was found that the sex products of the Aquarium whitefish began their development after June, entered the phase of rapid growth sometime after September and completed this phase sometime before March or February(?) sexual maturity could account for the cessation in body and scale growth in August or September. Sexual maturity would then be a primary factor in the formation of annuli in the adults.

It has thus far been shown that the scales of the Aquarium whitefish ceased growing sometime in August or September and resumed growth in April or March(?), that sexual maturity was reached sometime between September and March or February(?), that the lowest temperatures of the aquarium water occurred in January to March inclusive, and that the amount of food required by the fish was less for the months of January to March inclusive than for the other months of the year. It was suggested that food could only have had secondary significance in the formation of annuli since the reduction of food was caused by some other factor which affected the appetite of the fish. It was further suggested that since reduction and increase in food consumption occurred synchronously with the decrease and increase in temperature respectively, and since the scales resumed their growth at the time of a rise in temperature in April, when sexual maturity could have had no influence on growth, temperature must be considered a primary factor in the formation of annuli. Lastly, since the sex products began their development at approximately the same time when a retardation or cessation of scale growth occurred in late summer, when the environmental factors of food and temperature were known to have been constant, it appears reasonable to assert that sexual maturity is also a primary factor in the formation of annuli in scales. If sexual maturity is not such a factor, then it must be conceded that the retardation or cessation of scale or body growth, and consequently the formation of annuli, is caused by some unknown physiological factor or factors of annual recurrence.

The year of life in which sexual maturity first occurred can only be conjectured. The break in the growth curve (a) of Fig. 144, which represents the average annual increments of the Aquarium whitefish, suggests that most of these fish attained sexual maturity in the third year of life. This suggestion agrees

with the statements of Evermann and Smith (1896, p. 300) and the U. S. Fish Manual (1903, p. 110) to the effect that the whitefish reach sexual maturity in the third or fourth year; and with the statement on p. 120 of the Fish Manual where it is asserted that three-year-old whitefish artificially reared in the hatchery at Northville, Mich., yielded a large number of eggs, a fair percentage of which were fertilized. My data on the wild whitefishes indicate that sexual maturity may be attained in the fifth and sixth years by whitefishes from Lake Huron proper and in the fourth year by those of the North Channel and Georgian Bay; but, an overwhelming majority of the available individuals of these years and localities appear to be immature. The wild whitefishes perhaps attain sexual maturity for the first time at an older age than has previously been assumed, or the first year of spawning may vary with the locality.

The attainment of sexual maturity in the third year by the Aquarium fish would also account for the apparent change in their appetite in the third winter of life. With sexual maturity eliminated, food and temperature must have been the only environmental factors of growth in the first two years of life. Temperature did not seem to impede the metabolism of the body very seriously as the young fish were always ready to eat. Restriction in food must then have been the principal factor in the formation of annuli in the first two years of life.

(d) Annual Rate of Growth

The lengths in millimeters attained by each Aquarium fish at the end of each winter of life (K_1, K_2, etc.), and the annual growth increments in mm. of each year (k_2, k_3, etc.) are shown in Table I. These values were obtained by the method described on pp. 385 and 386 and the formula given on p. 383 from the diameter of scales. The average length and increment for each year is given at the bottom of the respective column. Below the calculated averages are shown corresponding averages of actual measurements of 238 Lake Huron whitefish taken at different localities in the fall of 1917 and 1919. In Fig. 144 are shown four growth curves based on the averages of Table I. Curve (a) represents the annual growth increments of the New York Aquarium whitefish, while curve (b) represents those of the Lake Huron whitefish. Curve (c) shows the total length reached by the aquarium fish at the end of each winter of life, while curve (d) shows the same thing for the Lake Huron fish.

From curves (c) and (d) it is at once evident that the Aquarium whitefish have been greatly retarded in growth. Knowing the limitations of their food and swimming space retarded growth is to be expected. Curves (a) and (b) show that in no year did the Aquarium fish attain the rate of growth of

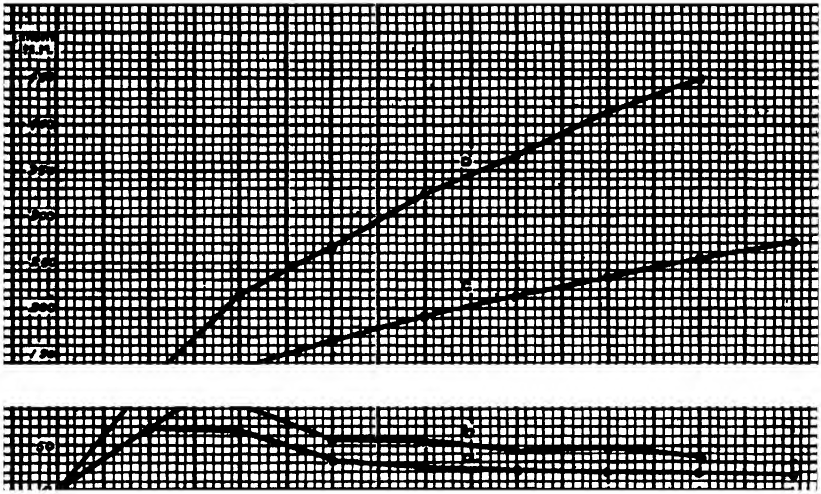


FIG. 144. Showing growth curves which represent the average total length in mm. attained at the end of each winter of life by the Lake Huron Whitefish (d). and the New York Aquarium Whitefish (c), and the average annual growth increments in mm. of each year of life of the Lake Huron Whitefish (b) and the New York Aquarium Whitefish (a). All curves are based on the averages of Table I.

the wild fish and that the greatest retardation in the growth of the Aquarium fish occurred in the first year of life. After the second year the annual growth increments were much reduced, but remained nearly constant to the eighth year in both series of fish.

The validity of the scale method is sometimes questioned because of the great range in the extreme lengths of the specimens placed by it in the same age group. This criticism is wholly refuted in column K, Table I. Specimens 54509 and 54510 of the same age and with the year's growth completed measure 219 and 334 mm. respectively, showing a difference in length of 115 mm., while specimen 54514, several months older than the two just mentioned, measures 9 mm. less than the first.

SUMMARY.

1. Scales were examined from whitefish hatched January, 1913, from eggs from the Put-in-Bay hatchery and reared in the New York Aquarium. The scales studied were removed from fish that were in their eighth and ninth year of life.

2. The annuli in the scales of the Aquarium whitefish are of the same number as that of the winters of the fish's life, the first one in which the fish were hatched excluded. The age of whitefish may therefore be determined from their scales.
3. The annuli in the scales of the Aquarium whitefish are winter-marks formed by the retardation or cessation of scale growth in late summer and winter and completed by the resumption of scale growth in the spring of the year.
4. The different dimensions (diameter, anterior and posterior radius) of whitefish scales grow at very different rates with respect to the rate of growth of the body and consequently the lengths and growth increments calculated from these dimensions vary significantly.
5. The anterior radius of the whitefish scale grows relatively faster than the body and consequently the lengths calculated from it are too low.
6. The posterior radius of the whitefish scale grows relatively much more slowly than the body and consequently the lengths calculated from it are much too high.
7. The diameter of the whitefish scale, on the whole, grows relatively only a little more slowly than the body and consequently the lengths calculated from it are only a little too high.
8. The lengths calculated from diameters are always higher than those calculated from anterior radii and lower than those calculated from posterior radii.
9. The diameter of scales seems to be a better basis for the length calculations of whitefish than the anterior radius which has nearly always been used in the past for many species of fish.
10. A rather complete life history of the New York Aquarium whitefish is given, which includes a statement as to the character of the food consumed, the number of feedings, the changes in the amount of food consumed, the temperature of the water in different months of different years, sexual maturity, spawning and the rate of body growth. The rate of body growth of the Aquarium fish is compared with that of Lake Huron whitefish. The significance of each of the above life history facts, rate of growth excepted, as a factor in the formation of annuli, is discussed.
11. Food is only a secondary factor in the formation of annuli in the adults studied, but may have been a primary factor in the immature fish.
12. Temperature appears to be a primary factor in the formation of annuli in the adults, but only a secondary one in the immature fish.

13. Sexual maturity appears to be a primary factor in the formation of annuli in the adults.
14. The method employed in the study of the scales of the Aquarium whitefish differs somewhat from those described and used by other investigators. The method and the apparatus used are therefore briefly described.

BIBLIOGRAPHY

ARWIDSSON, IVAR

1910 Zur Kenntnis der Lebensgeschichte der jungen Lachse in den Flussen von der Hinabwanderung ins Meer. Conseil Permanent International pour l'Exploration de la Mer. Publications de Circonstance, No. 54, 86 pp., Copenhagen.

BROWN, A. WALLACE

1904 Some Observations on the Young Scales of the Cod, Haddock and Whiting before Shedding. Proc. Roy. Soc. of Edinburgh. Vol. XXIV, for 1901-1903. pp. 437-438. Edinburgh.

CUNNINGHAM, J. T.

1905 Zones of Growth in the Skeletal Structures of *Gadidae* and *Pleuronectidae*. 23d Ann. Rep. Fish. Board Scotland, pt. III. App. V. pp. 125-140. Glasgow.

CUTLER, D. WARD

1918 A Preliminary Account of the Production of Annual Rings in the Scales of Plaice and Flounders. Journ. Marine Biol. Assoc., n. s. Vol. XI. No. 4. pp. 470-496. Plymouth.

EVERMANN, B. W., AND SMITH, H. M.

1896 The Whitefishes of North America. App. 4, Report U. S. Commissioner of Fish and Fisheries for 1894. Washington.

FRASER, C. MCLEAN

1917 On the Scales of the Spring Salmon *(Oncorhynchus tschawytscha.)* Contr. Can. Biol., 1915-1916. Ottawa.

FULTON, T. W.

1904 The Rate of Growth of Fishes. 22nd Ann. Rep. Fishery Board, Scotland. pt. III. pp. 141-241. Glasgow.

HOFFBAUER, C.

1898 Die Altersbestimmung des Karpfen an seiner Schuppe. Allgemeine Fischerei-Zeitung, nr. 19, Oct. 1, 1898. Jahrg. XXIII. Art. III. pp. 341-343. Munchen.

1899 ——— Jahres Bericht des Schlesischen. Fischerei-Vereins.

1901 Weitere Beitrage zur Bestimmung des Alters und Wachstumsverlaufes an der Struktur der Fischschuppe. Jahresber. der Teichwirthschaftl. Versuch-Station zu Trachenberg.

HUTTON, J. ARTHUR

1914 Recent Investigations upon the Life History of the Salmon by the Board of Agriculture and Fisheries. Salmon and Trout Magazine. No. 7. 28 pp. London.

JACOT, ARTHUR PAUL
1920 Age, Growth and Scale Characters of the Mullets, Mugil cephalus and Mugil curema. Trans. Amer. Micros. Soc., July. Vol. XXXIX. No. 3. pp. 199-229.

MASTERMAN, A. T.
1913 Report on Investigations upon the Salmon with Special Reference to Age Determinations by Study of Scales. Board of Agric. and Fish. Fishery Investigations. sr. I. Salmon and Fresh-water Fish. Vol. I. pp. 1-80. London.

RICH, WILLIS H.
1920 Early History and Seaward Migration of Chinook Salmon in the Columbia and Sacramento Rivers. Bull. U. S. B. F. Vol. XXXVI, 1919-20. Doc. No. 887. Washington.

SCOTT, THOMAS
1906 Observations on the Otoliths of Some Teleostean Fishes. 24th Ann. Rep. Fish. Board, Scotland. pt. III. App. II. pp. 48-52. Glasgow.

TAYLOR, HARDEN F.
1916 The Structure and Growth of the Scales of the Squeteaque and the Pigfish as Indicative of Life History. Bull. U. S. B. F., Vol. XXXIV, 1914, Doc. No. 823, Sept., pp. 289-330. Washington.

THOMSON, J. S.
1904 The Periodic Growth of Scales in Gadidae as an Index of Age. Journ. Marine Biol. Assoc., N. S. VII, pp. 1-109. Plymouth.

TIMS, H. W. MARETT
1906 The Development, Structure and Morphology of the Scales in Some Teleostean Fish. Quarterly Journ. of Microscopical Science, Vol. XLIX, No. 193, n. s. Oct., 1905, pp. 39-68. London.

U. S. FISH MANUAL
1903 Artificial Propagation of the Lake Trout, Grayling and White-fish. Washington.

WALTER, E.
1901 Altersbestimmung der Karpfen nach der Schuppe. In: Knauthe, Die Karpfenzucht, pp. 88-122. Neudamm.

region of the female. Hence, the egg of *H. crucifer* is apparently fertilized while held in the cloacal orifice of the female, while it may or may not be fertilized at this time in the case of *H. andersonii.* The ovipositions of *H. andersonii* and *H. crucifer* may be compared as follows:

H. crucifer	*H. andersonii*
(1) Cloaca upturned, and egg or its capsule (rarely two eggs) appears in orifice of cloaca.	(1) Back bowed greatly, and cloaca upturned; part of a bunch of eggs (7 to 14) appear in orifice of cloaca.
(2) Cloaca of female usually touches posterior ventral surface of male's body in upward movement.	(2) Same.
(3) Emission of spermatozoa apparently takes place as cloaca touches or passes near ventral surface of male.	(3) Same.
(4) Back straightened and cloaca of female brought forward beneath body where the egg (or eggs) is shot out against some object to which it adheres.	(4) Back straightened and eggs are shot out against body of male to which they do not adhere, but glance off to the bottom of the pond.

The remainder of the egg-laying process of *H. andersonii* cannot be compared in detail with that of *H. crucifer.* At the moment the eggs are extruded, the hind limbs of the female are convulsively straightened, forcing the pair forward in the water. The female makes one or two nervous half strokes which continue the headway of the first stroke. In one to three seconds they have again come to rest, the female again bows her back and the process is repeated. After two to ten (possibly more) layings, the pair come to rest and oviposition may not continue until half an hour later. The exact length of these "rests" between sexual periods were not determined in the field. In the laboratory this "rest" was extremely variable.

The most remarkable feature of this egg-laying is the course taken by the eggs (Fig. 150). The female bows her back very much as in the case of the ovipositing *H. versicolor,* and even makes

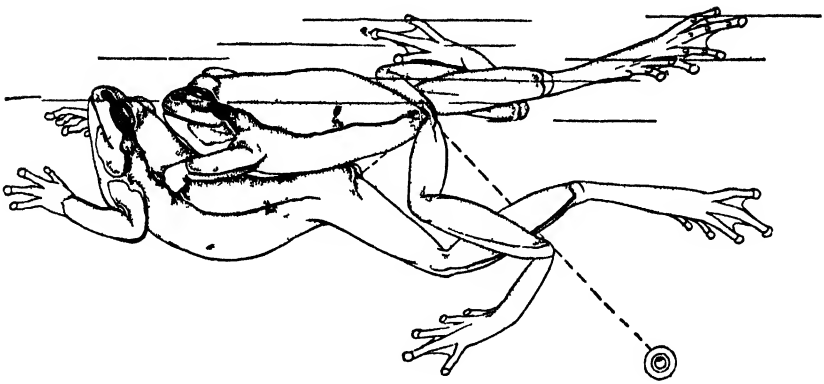


FIG 150 THE OVIPOSITION OF *HYLA ANDERSONII*

This bombardment of the male with eggs seems to be a specialization derived from the method of oviposition found in *H versicolor* where the female lifts her cloaca above the water In this diagram only one egg has been represented (instead of nine) and the legs of the male have been abnormally extended in order to show better the course of the eggs

some attempt to raise the cloaca above the water, as in that species, but the eggs never (or very rarely) reach the surface of the water. On being shot from the cloaca they strike the male on his ventral surface immediately below his cloaca and are carromed off to the bottom of the pool. Of the many times we watched this bombardment of eggs both in the two pairs studied in the field, and the laboratory specimens, only twice—and then in laboratory specimens—did we see the eggs miss the posterior part of the male's ventral surface. In these cases the eggs missed the male entirely and fell considerably to the rear of the pair.

This phenomenon of egg bombardment is of special interest from a phylogenetic point of view. The eggs of most species of *Hyla* float. In the case of *H. versicolor*, it would seem that the air bubbles entangled in the jelly when the female raised her cloaca above water, caused the eggs to float. In other forms it would seem more likely that it was some phenomenon of surface tension (Harrison 1922) holding the eggs near the surface where they were laid. Now in *H. andersonii*, the eggs cannot reach the surface for a very definite mechanical reason,—namely, the male is in the way. Nevertheless, the female goes through all the movements as if intending to

lay the eggs on the surface of the water. It would thus seem that in *H. andersonii*, its habit of laying bottom eggs has been derived from the more characteristic surface egg habit.

The eggs of *H. andersonii*, although shot from the cloaca in bunches of from seven to fourteen (average, nine), do not adhere to one another. They fall to the bottom of the pool where they usually adhere to sphagnum or debris. Here they swell rapidly and frequently lose their attachment to the sphagnum. At Lakehurst, many eggs (in late cleavages) were found lying free on the bottom of the sphagnaceous streams.

In nature, *H. andersonii* was estimated to lay eight hundred to one thousand eggs. None of our laboratory animals laid more than eight hundred eggs.

The Egg and Its Capsules.

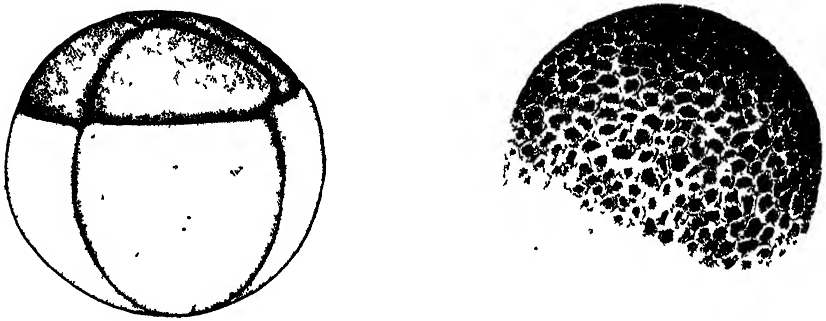
The eggs of *H. andersonii* may be readily distinguished from all other eggs found in the pine-barrens by the following characters: The eggs are—

1. Single, not adhering to one another, usually scattered among the water weed.
2. Attached to sphagnum (rarely debris), or free and rest on bottom.
3. Found on bottom of small, non-stagnant pools, or in slow-moving streams of the pine-barrens.
4. With dark cap of the animal pole extending only over one-third of the surface of the egg. (Early cleavage stage.)

Before cleavage the cap on the animal pole is usually dark brown, the other two-thirds of the egg, creamy-white. As the cleavage continues, new pigment is formed. At the end of cleavage, before any gastrulation has begun, about two-thirds the surface of the egg is pigmented (Fig. 151). Harrison (1922) has noticed a similar phenomenon of pigment increase during segmentation in some of the Australian hylas he studied. In making a comparison of the eggs of *H. andersonii* with the eggs of other frogs, care should be taken to use only eggs very recently laid, not those which have gone beyond the 32 cell stage.

As gastrulation continues, the egg becomes much lighter in color. The late gastrula is pale brown, often with streaks of a darker tone.

The egg is surrounded by the vitelline membrane and by the



a b

FIG 151 PIGMENTATION OF THE EGG OF *H ANDERSONII*

a Eight cell stage viewed from side of the gray crescent *b* Late cleavage stage, to show the increase of pigmentation

two gelatinous membranes of the usual type. The gelatinous capsules vary enormously according to their age, and treatment. The following measurements are taken from a series preserved in formalin. They agree well in size with some living specimens.

Diameter of Ovum—1.2–1.4 mm.
" " Inner Capsule—1.9-2.0 mm.
" " Outer Capsule—3.5–4.0 mm.

The vitelline membrane may be best demonstrated just after maturation when the animal pole is slightly flattened leaving a space between membrane and ovum.

In passing, a word may be said in regard to egg membranes in general. The eggs of most batrachians possess two gelatinous capsules in addition to the vitelline membrane. European pelobatids are stated by Boulenger (1898) to possess only the inner capsule, while Wright (1914, p. 16) allows us to infer that some American Salientia may lack the same. We should like to emphasize that the outer egg capsule of all batrachians is subject to great modification, even within a species. Thus, our pelobatid *Scaphiopus holbrookii* has two layers of "jelly" about the eggs. At oviposition, the outer layer is extremely adhesive. As development continues, this outer capsule swells rapidly, losing its adhesive quality, and changing its appearance.[1] We do not believe that the presence or

[1] The eggs of *S. holbrookii* are not twisted around the grasses in the spiral manner indicated by Deckert (in Overton 1914); on the contrary, they are laid on the upper side of grass stems which have been flattened down by the female. As the outer gelatinous membrane swells, the egg-masses take on the appearance of being arranged in a spiral, having much the same form as the egg-masses of European pelobatids.

absence of the outer capsule in all batrachian eggs can be determined without investigating the structure of these membranes at the moment of oviposition.

We have had no difficulty in distinguishing two gelatinous capsules in the living eggs of *H. crucifer*, although Wright (1914) figures only one capsule.

Development of the Egg.

The egg of *H. andersonii*, in spite of its reduced pigmentation, shows some indication of a "gray crescent." At least one side of the fertilized egg is paler than the other. The pale region is in no sense a crescent, but is an area probably homologous to the gray crescent of *Rana*. The first cleavage plane tends to cut the mid-point of this "crescent" at right angles. However, some irregularities occur. The second cleavage plane is as usual meridional, but in most eggs it cuts the first cleavage plane not at its mid-point, but nearer the "crescent" side. As a result, the two cells containing the crescent material are usually smaller than the opposite pair. The third cleavage is latitudinal. It cuts the egg at right angles to its axis and at such a point that on the "crescent" side the third cleavage furrow sharply demarcates the pigmented from unpigmented region. Later cleavages are usually irregular. This is probably due to the fact that the second cleavage plane does not cut the egg systematically, but leaves less material on the "crescent" side than on the other. It would be interesting to know the conditions in other species of *Hyla*.

With the little comparative material available to us it does not seem advisable to discuss the later stages in any detail. The changes of pigmentation which accompany the development within the egg have been mentioned above. The late gastrula shows some dorsal flexure as in *Bufo* and *Rana*. No marked differences between the gastrulation in these groups were noted.

Eggs laid in the laboratory hatched in four days. This is probably a much shorter period than would occur in nature. Although the period of development within the egg may be greatly modified by temperature, not all eggs placed under identical conditions develop in the same time. Wright (1914, p. 19) found that the eggs of the species he considered all developed in about the same time under laboratory conditions,—namely, in four or five days. But Boulenger (1898) has found a marked difference in the

developmental period of two such allied genera as *Alytes* and *Discoglossus*. We have found that the eggs of *Scaphiopus* hatched within thirty-six hours, while the eggs of most species of *Rana* require five days under the same conditions.

Lastly, a word may be said in regard to laboratory conditions. If a breeding pair is placed in a very small container, the chances that all the eggs will be fertilized and develop are very much better than if they are in a large jar. We experienced none of the difficulties with our material that Wright (1914) mentions.

The Adhesive Organs and Their Development.

Very few have studied the adhesive organs of batrachian larvae. Although the form of these organs differs in the various species and may be utilized as a character diagnostic of the species, these organs have been described in only a few hylids. It is, therefore, perhaps not surprising that we should find that the adhesive organs of *H. andersonii* bridge, during their ontogeny, the gap supposed to exist between the bufonid and hylid types.

Thiele (1888, pl. 10) found that the adhesive organs of *H. arborea* arose as two swellings, one on either side of the midline in a way very similar to the ontogeny of these organs in *Rana agilis*. Thiele pointed out that the more primitive method of development was that of *Pelobates* and *Bufo*, where the organs arise by modification from a crescentic furrow. It is, therefore, of considerable interest that we should find some indication of this crescentic type of development in *H. andersonii*.

In the early embryo of *H. andersonii* there appears a crescentic swelling on the ventral surface of the head (Fig. 152). This becomes slightly more pigmented than the surrounding region, but never invaginates to form a furrow as in European species of *Bufo*. As development continues, the two horns of the crescent increase in size and gradually differentiate into the definitive adhesive organs, while the posterior part of the crescent (Fig. 152) becomes less and less distinct.

By the time the tadpole is ready to hatch, the adhesive organs have assumed a position lateral to the mouth. It will be noticed from fig. 152 that these organs, when fully formed, are not as far anterior as the adhesive organs of *H. arborea*. In *H. crucifer* we find that the adhesive organs have a similar position lateral and posterior to the mouth.

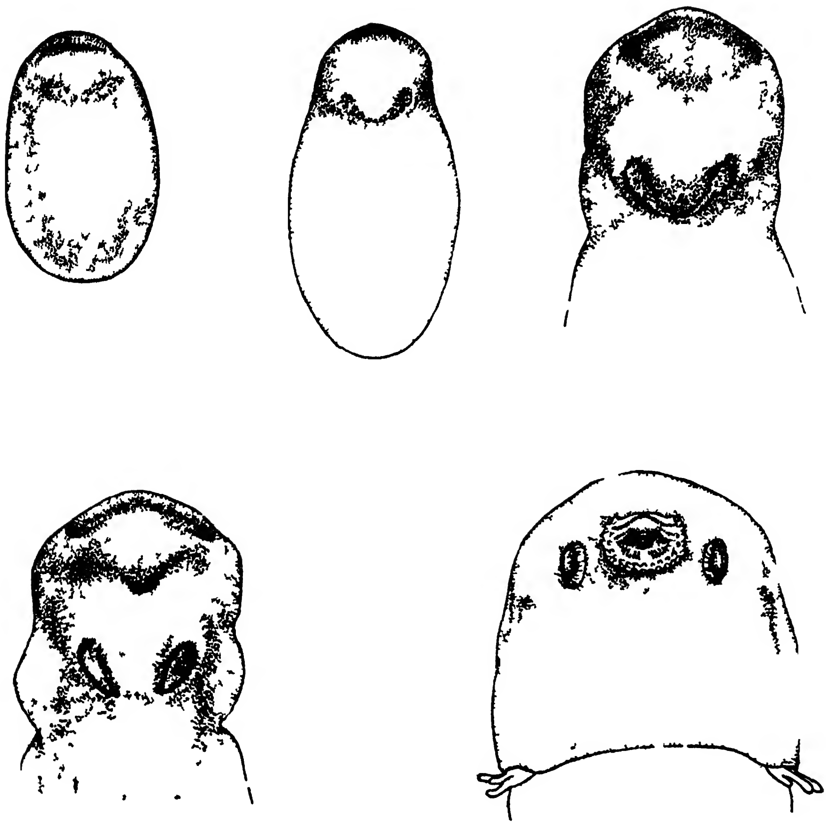


FIG. 152. DEVELOPMENT OF THE ADHESIVE ORGANS
All but the last stage occur within the egg capsules. The frontal organ (extreme anterior end) is conspicuous in all but the last stage.

It will be noticed from fig. 152. that the frontal organ in *H. andersonii* is very distinct. This would indicate that it must have considerable functional significance.

Development of the Tadpole.

Eggs raised in the laboratory in shallow watch glasses hatched four days after oviposition. The recently hatched tadpoles varied somewhat in size, an average specimen measuring 4.5 mm. in total length. The color of these tadpoles was pale yellow finely stippled or suffused with brown. As the tadpoles grew older the pigment

became darker. Approximately five days after hatching some indication of the distinctive pattern of the mature tadpole appeared. The pigment of the head first increased on the inner wall of the lymph space just anterior to the eye. This gave the tadpole a "pathological appearance" as though it carried two blisters, one on either side of the snout (Fig. 153*b*). Pigment developed slowly in the outer wall of this lymph space. It was not until just before the appearance of the posterior limb buds that the tadpole lost these "blisters."

The color pattern became well established in tadpoles of 11 mm. in length. Living specimens were uniform dull, chocolate brown above, golden or bronzy below. A dark stripe early made its appearance on the upper half of the fleshy part of the tail (Fig. 153c). An irregular series of blotches of the same dark brown developed above the stripe on the upper tail fin and a few smaller ones on the lower fin. (Fig. 153*c*.)

Only two external gills ever develop in the tadpole of *H. andersonii*. These are pigmented like the body. Each gill consists of a single stalk with four branches. Three of the branches of each of the anterior gills become well developed while the fourth remains a mere bud. Only two of the branches of the posterior pair of gills elongate, the other two branches of each gill remaining as short stumps. The longest gill measures only .7 mm. (three days after hatching). It is about as long as the diameter of the eye (which, although hidden beneath the skin, is visible in both living and preserved specimens).

In laboratory specimens the operculum grew over the external gills six days after hatching. The tadpoles at this age averaged 8 mm. in total length. The pale coloration of the early tadpole had darkened, and some indication of the dark tail streak had appeared. Although the mandibles were well formed and pigmented, no horny teeth had yet developed. The vent at this stage had just begun its asymmetrical growth which soon resulted in its characteristic dextral twist.

The horny teeth began to develop immediately. As the tadpole matured, the teeth increased in number. This may be seen in our series of preserved specimens. In a tadpole of 11.5 mm. total length, the number of teeth in each row, reading the rows from above down, is as follows: 38/10 + 10//31/24/5. In one of 17 mm., the formula is: 52/21 + 21//47/45/21. In a mature tadpole of 32.5 mm. total length and having the limb buds well developed, the formula is as

follows: 96/36 + 35//67/82/40. The number of teeth in each row is closely correlated with the relative extent of the row. Hence, little may be said about the diagnostic value of the teeth rows of *H. andersonii* unless they be compared with those of a tadpole of the same age. The mouth parts figured above (Fig. 153*a*) are those of the tadpole figured (Fig. 153*c*).

Perhaps the most distinctive feature of the tadpole of *H. andersonii* is its short and narrow tail fin (Fig. 153*c*). This gives the tadpole a Rana-like appearance, or at least permits one to readily distinguish it from the tadpole of *H. versicolor*, or that of *H. arborea.* The question may be raised: is this reduced fin an adaptive feature? It may possibly be such, but the evidence at this time is by no means clear. The tadpoles of *H. versicolor* live for the most part in quiet, weedy ponds and these broad fins aid them to make quick turns very much in the same way that flattened or deep-finned fishes are able to dodge suddenly when avoiding an enemy. But let us look further. Most of the vertebrate inhabitants of the pond are deep-bodied or deep-finned. The ambystomid larvae have a back fin which undoubtedly serves them in their jerky dashes. A glance at a neighboring brook and we have a different picture. Here most of the forms have reduced the fin and have adopted better "stream lines." This is especially noticeable in the larvae of *Desmognathus* and *Eurycea.* The rule holds true for practically all mountain brook salamanders as *Rhyacotriton* in this country and many exotic genera. In the puddles of the slower streams we sometimes find the narrow-finned tadpoles of *Rana pipiens* or *Rana clamitans.* The comparison, however, between brook salamanders and brook tadpoles may not be drawn too closely. Frequently narrow-finned tadpoles occur in the ponds. It is interesting, however, that the tadpole of *H. andersonii* dwells primarily in the slow streams of the pine-barrens, and as if in adaptation to the current, it has given up its broad "pond life fin" for the sake of a more efficient one. We say "given up," for it seems probable from what has appeared above, that the species was evolved from a type having much the habits of *H. versicolor.* Whether or not we have pushed too far this comparison of brook salamanders and brook tadpoles, the fact remains that *H. andersonii* with its short fin has much more the habits of a *Rana* or a *Bufo* tadpole than it has the characteristic *Hyla* mannerisms (*see below*).

Metamorphosis first occurred at Lakehurst in the area under

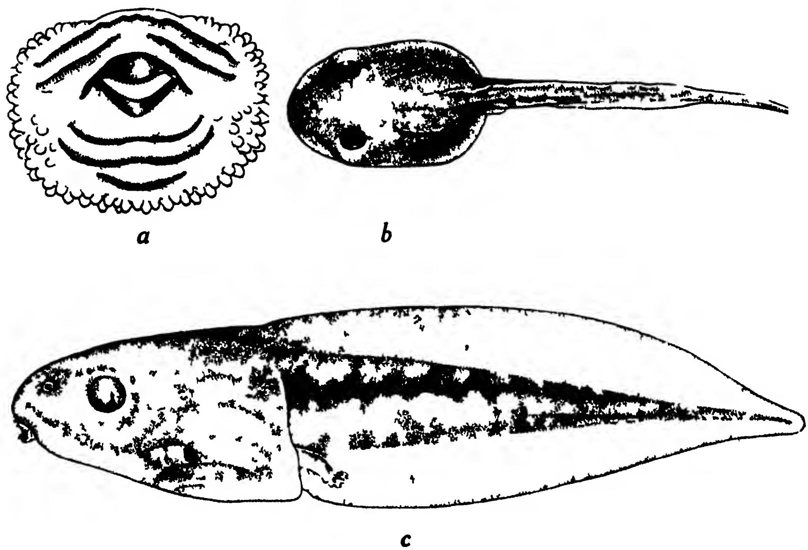


FIG. 153. TADPOLES OF *HYLA ANDERSONII*

a The mouth parts of mature tadpole. *b* Early tadpole showing the conspicuous lymph sacs on either side of the snout. *c* Mature tadpole showing the characteristic pattern.

observation on July 23. None of the laboratory animals reached metamorphosis, probably because of our limited supply of bog water. Metamorphosis usually followed the day after the right fore-limb appeared. The left fore-limb appeared usually a day before the right limb. The spiracle became greatly widened to permit the passage of the left limb through it. The usual phenomena of metamorphosis occurred. The head widened, the mouth changed its shape and the body decreased in size. The head and body length (excluding the tail) of five tadpoles, having only the posterior limbs present, averages 13.1 mm., the head and body length of five others, having all four limbs present and the head already changed in form, averages 12.1 mm. Metamorphosing tadpoles became slightly greener in coloration but did not assume the full color of the adult while in the water.

Description of a Mature Tadpole

A tadpole is said to be mature at the time of the appearance of the hind limbs. In some forms this does not correspond to the full

development of larval characteristics. In *H. andersonii* the larval color pattern may or may not be complete at this stage. For this reason, we have utilized slightly older specimens in drawing up the following description. As is customary in the describing of adult batrachians, the detailed description is based upon a single typical specimen, the diagnosis upon several specimens.

Diagnostic Characters Spiracle sinistral, anus dextral, eyes visible from the vental surface, upper fin crest not extending beyond the vertical of the spiracle, distance from spiracle to base of hind limb contained about 1.3 times in its distance from the snout; labial teeth 2/3. Uniform brown above, yellowish on the tail, a conspicuous irregular stripe of dark brown extending the length of the tail. Greatest length of tadpole, 35 mm.

Detailed Description Length of body contained 2.6 times in the tail length; width of body 1.7 times in its own length; nostril nearer the eye than the tip (midpoint) of snout; eye dorso-lateral, visible in part from the ventral surface, nearer the snout than the spiracle; distance between nostrils contained 1.66 times in the interorbital width, exactly equal to the width of the mouth; spiracle sinistral, its distance from the base of the hind legs 1.29 times in its distance from the snout; anus dextral; depth of the muscular portion of the tail at its base contained 2.5 times in the greatest depth of the tail.

Upper labium with two series of teeth, a boundary row of teeth and an inner or lateral row on each side (Fig. 153*a*); the median space between these two lateral rows only a third the length of one of the lateral rows; three continuous rows of teeth on the lower labium, the second or median longest, the outer or boundary row slightly more than half as long as the median one; a complete circlet of papillae around the mouth, broken only for a short space along the upper median margin; a clump of papillae at either corner of the mouth, medial to the boundary papillae.

General color (formalin preservation) of the body, chocolate brown above, translucent below; tail yellowish; an irregular streak of dark brown running the length of the fleshy part of the tail just dorsal to the median line; lower border of the fleshy part of the tail irregularly spotted with a slightly paler brown; tail fin both above and below streaked or finely spotted with brown; the streaks sometimes forming irregular stellate figures but never a network.

In life the color pattern was the same, the brown and yellow tones of about the same intensity. The belly was very different.

It was golden, irridescent or whitish, according to the direction of the light. The throat was yellowish. The iris was golden, vermiculated with black; the black pupil was large and round. Some indication of internal structure visible, especially the nasal passage and two of the posterior cranial nerves. Lateral line system feebly indicated.

Measurements

Total Length	31.0	mm.
Greatest length of head and body	12.5	"
Greatest length of tail	18.5	"
Greatest depth of tail	7.5	"

Habits of the Tadpole.

Larvae raised in the aquarium and those studied in the field had similar habits. The larvae of *H. andersonii* are not active swimmers. At Lakehurst, these tadpoles seek out the shallows whether or not these be weed-grown. In such favored places, great numbers of tadpoles were found resting motionless just below the surface with dorsal crest touching the surface film. When approached they dived quickly into the nearest masses of sphagnum. Tadpoles of *H. andersonii* exhibited similar resting and diving behavior in the laboratory. No other tadpoles with which we are familiar make such erratic plunges into concealment.

Laboratory specimens ate some fish food (dried shrimp) and some of the water weed in their aquaria. They invariably skeletonized within a day any of their companions that died.

Food Habits.

The food habits of *H. andersonii* are in no way specialized. This is to be expected since it has been shown elsewhere (Noble, in press) that the food habits of most tree frogs do not radically differ from those of frogs living near the water's edge. Frogs and toads seize anything of small size moving in their vicinity.

The stomachs of ten males which were captured during June while calling from bushes or low trees contained the following food: 5 grasshoppers (two species); 2 beetles, 3 ants (2 species), 1 dipterous insect, 2 dipterous pupae (tabaniid?), and some unidentifiable insect remains. None of the specimens taken in embrace contained

food in their stomachs, but only a few pairs were killed immediately after oviposition.

RELATIONSHIPS.

H. andersonii has been generally considered a close relative of the European Tree Frog. Long ago Cope (1889) said of *H. andersonii,* "in proportions and general appearance similar to *Hyla arborea* of Europe." Since then everyone who has had the occasion to consider the relationships of *H. andersonii* has agreed that the resemblance was very close. More recently, Barbour (1914, p. 239) has expressed the opinion that *Hyla pulchrilineata* of Santo Domingo was allied to *Hyla arborea.* We have recently had the occasion to study *H. pulchrilineata* in the field, and could find very little resemblance between these two species in either color, structural characters, voice, vocal-pouch, breeding habits, or in any other than generic characters. In a paper now in preparation, we have concluded that the two species are only distantly related.

As pointed out above, the object of the present paper is to describe those features of the habits and life history of *H. andersonii* which might shed light on its relationships. As no one has previously attempted to ally *H. andersonii* to any other species than *H. arborea,* it is important that we should first consider the resemblances and then the differences between the two species. Our information in regard to *H. arborea* is taken chiefly from Boulenger (1898).

Resemblances between *H. andersonii* and *H. arborea.*

1. General color and proportions.
2. Small size.
3. Many structural features,—as smooth skin, position of vomerine teeth, form of nuptial asperities, form of vocal pouch, etc.

Differences between *H. andersonii* and *H. arborea.*

1. Color pattern differs in many details of which the most noteworthy are as follows: the lumbar and the dorsal spots frequently found in *H. arborea* are never present in *H. andersonii;* the ground tone of *H. arborea* is subject to variation of color, of *H. andersonii,* to only a change of intensity; the details of coloration of thighs, throat and often the appendages differ remarkably in the two species.

2. Contracted pupil of *H. arborea* diamond-shaped; not so in *H. andersonii.*

3. Fingers slightly webbed in *H. arborea*; free in *H. andersonii.*

4. A strong odor of "raw peas" from *H. andersonii* after handling; no such odor from *H. arborea.*

5. A marked sexual dimorphism in *H. andersonii*; not so in the other species. In *H. andersonii*, as pointed out above, there is a difference between the sexes in the size, in the color on the sides of the throat, and in the ground tone of the throat. These differences do not appear in the several specimens of *H. arborea* before us. A breeding pair taken at Blois, France, measures 42 mm., total length in both sexes. A female of *H. arborea* from Germany measures 41 mm., while four non-breeding males from Germany measure 40.5, 40.5, 36.5 and 35 mm. respectively. Thus, there might be a slight difference in size between the sexes of *H. arborea*, but this difference is not constant. There seems to be no sexual dimorphism in *H. arborea* other than some indication of breeding asperities in the male, and sometimes a difference in size between the sexes.

6. The call of the two species is radically different. The following notes have been kindly given us by Dr. J. P. Chapin.

> "In company with Dr. R. E. B. McKenny, at Blois, on the River Loire, France, during April, 1918, I found eight or ten individuals of *Hyla arborea* assembled just after dusk in a temporary pond in an open grassy field. Their notes, by which we were attracted, bore no resemblance to the voice of *Hyla andersonii*, with which I was very familiar; on the contrary, they produced a confused, hoarse, croaking chorus, which reminded me far more of the voices of common European toads. There was nothing of the curious nasal resonance of the "quank" of *andersonii.* The behavior of the individual frogs, too, was very different. They were all in the water while calling, not perched in bushes, as is usual with *andersonii;* and from the number of them in one or two small pools, I might describe them as far more sociable. In view of the striking external resemblance between *andersonii* and *arborea*, I was greatly impressed by the dissimilarity of their voices and actions."

7. The habitat of the two species differs greatly,—*H. andersonii* being confined to the pine-barrens, while *H. arborea* has a wide distribution in many types of country throughout Europe.

8. The breeding cites of *H. andersonii* are always shallow sphagnaceous streams or puddles on the pine-barrens, while

H. arborea selects "deep pools or ponds of clear water, more or less richly endowed with vegetation," (Boulenger, 1898, p. 258). Thus, *H. arborea* agrees with *H. versicolor* in the selecting of a breeding cite and differs remarkably from *H. andersonii*. Deep ponds are available to *H. andersonii* but it selects only the small pools.

9. Eggs of *H. arborea* are deposited "in several lumps, . . . attached to weeds below the surface of the water" (Boulenger, 1898, p. 259) Many more eggs are laid at one time by *H. arborea* than by *H. andersonii*, and these are adherent in the former species, not in the latter. From the form of the egg-masses, their attachment to weeds, and the number of eggs, it is apparent that the method of oviposition in *H. arborea* must be very unlike that of *H. andersonii*.

10. The external gills of *H. arborea* are "unbranched or bifid"; in *H. andersonii* there are only two pairs of gills, the posterior pair having two well developed branches, the anterior pair, three such branches.

11. The adhesive organs arise separately in *H. arborea*; in *H. andersonii* they develop from a crescent somewhat as in *Bufo*. The final position of the adhesive organs is more anterior in the former than in the latter species.

12. The mature tadpole of *H. andersonii* differs radically from that of *H. arborea* in the extent of its fin crest, and in its coloration both above and below. It also differs in having its eyes more dorsal and in having somewhat different proportions.

13. The mature tadpole of *H. andersonii* differs from that of *H. arborea* in its habits. It is a slow-moving form, accustomed to bask in the sun with dorsal fin in contact with the surface film. The description of the tadpoles of *H. arborea* given by Boulenger reminds us very much of *Scaphiopus* tadpoles for they are found "swimming about like fish in every direction."

14. Activity of the adults of the two species differ. *H. andersonii* does not stick well to smooth surfaces; when it climbs it frequently grips the branch with opposed fingers (Fig. 148*h*) and the feet wrap around the support. The movements of *H. arborea* agree well with the majority of hylas.

The above differences are far too numerous to be disregarded, for some of these differences are of considerable consequence. The resemblances between *H. arborea* and *H. andersonii* do not outweigh the differences. We have examined specimens of *H. regilla* which seem as nearly like *H. andersonii* as do some specimens of *H. arborea.* The resemblance in color pattern may be due to convergence, for Boulenger looks upon the spotted pattern as the more primitive and ancestral to the unspotted type, at least in the *H. arborea* group of forms. Further, Boulenger (1898, p. 252) considers that *Hyla immaculata,* described by Boettger, from China as a race of *arborea* "cannot be united with *H. arborea* . . . as it lacks the web between the fingers." *H. andersonii,* too, lacks the web between the fingers, and the question is immediately raised whether it might not be closely allied to *H. immaculata.*

It may be further pointed out that both botanically and herpetologically there are as good *a priori* grounds for seeking the ancestral stock of a form, at present restricted to eastern United States, not in western Europe, but in eastern Asia. *Cryptobranchus* and *Leiolopisma* are two striking examples of American forms having close allies in China. To this list we may now add *H. andersonii.*

CONCLUSIONS.

1. *H. andersonii* is not closely related to *H. arborea* nor to *H. pulchrilineata.*
2. *H. andersonii* has been derived from a group of hylas which laid surface eggs, its method of oviposition being a modification of their method.
3. *H. andersonii* exhibits a primitive method of adhesive organ formation.
4. Voice plays an important rôle in the mating of *H. andersonii* and probably in other American tree frogs.
5. *H. andersonii,* by its coloration (including sexual dimorphism), method of oviposition, distinctive tadpole, and restricted habitat, occupies an isolated position among American species of *Hyla.*
6. The relationships of *Hyla andersonii* are to be sought in Chinese forms and probably in *H. immaculata* (Boettger).

BIBLIOGRAPHY

ABBOTT, CHARLES C.

1868 Catalogue of Vertebrate Animals of New Jersey, *in* Cook. Geology of New Jersey, Appendix E.

1890 Voice of *Hyla andersonii.* Amer. Nat., Vol. XXIV, p. 189.

BAIRD, SPENCER F.

1854 Descriptions of New Genera and Species of North American Frogs. Proc. Acad. Nat. Sci. Phila., Vol. VII, pp. 59-62.

BARBOUR, T.

1914 A Contribution to the Zoogeography of the West Indies, with Especial Reference to Amphibians and Reptiles. Mem. Mus. Comp. Zool., Vol. XLIV, pp. 204–359, 1 pl.

1916 A Note on Two Interesting New Jersey Amphibians Copeia, No. 26, pp. 5–7.

BLES, E. J.

1906 The Life-History of *Xenopus laevis,* Daud. Trans. Roy. Soc. Edinburgh, Vol. XLI, pp. 789–821, pls. 1 to 4.

BOULENGER, G. A.

1882 Catalogue of the Batrachia Salienta . . . of the British Museum. London.

1898 The Tailless Batrachians of Europe, Parts I and II. London.

1912 Some Remarks on the Habits of British Frogs and Toads, Proc. Zool. Soc. London, pp. 19 22.

COPE, E. D.

1862 On some new and little-known American Anura. Proc. Acad. Nat. Sci. Phila., Vol. XIV, pp. 151–159.

COURTIS, S. A.

1907 Response of Toads to Sound Stimuli. Amer. Nat., Vol. XLI, pp. 677–682.

CUMMINS, HAROLD

1920 The Rôle of Voice and Coloration in Spring Migration and Sex Recognition in Frogs. Journ. Exp. Zool., Vol. XXX, pp. 325–343.

DAVIS, WILLIAM T.

1904 Note on Hyla Andersoni, Baird. Proc. Nat. Sci. Assoc. Staten Island, Vol. IX, p. 26.

1904a Hyla andersonii and Rana virgatipes at Lakehurst, New Jersey. Amer. Nat., Vol. XXXVIII, p. 893.

1905 Further Note on *Hyla andersonii* and *Rana virgatipes* in New Jersey. Amer. Nat., Vol. XXXIX, pp. 795–796.

1907 Additional Observations on *Hyla andersonii* and *Rana virgatipes* in New Jersey. Amer. Nat., Vol. XLI, pp. 49–51.

1922 Insects from North Carolina. Journ. N. Y. Entom. Soc., Vol. XXX, pp. 74–75.

DECKERT, R.
1918 Two Interesting Tree Toads. The Aquarium Bulletin, Brooklyn, N. Y., pp. 125–126.

DICKERSON, MARY C.
1906 The Frog Book, New York.

DITMARS, RAYMOND L.
1905 The Batrachians of the Vicinity of New York City. Amer. Mus. Journ., Vol. V, pp. 161–206.

FOWLER, HENRY W.
1907 The Amphibians and Reptiles of New Jersey, *in* Ann. Rept. N. J. State Museum for 1906, pp. 23–250.
1909 Notes on New Jersey Fishes, Amphibians and Reptiles, *in* Ann. Rept. N. J. State Museum for 1908, pp 349–408.

HARRISON, LAUNCELOT.
1922 On the Breeding Habits of Some Australian Frogs. The Australian Zoologist, Vol. III, pp. 17–34.

HARSHBERGER, J. W.
1916. The Vegetation of the New Jersey Pine Barrens, An Ecological Investigation. Philadelphia.

KUNITOMO, K.
1910 Uber die Entwicklungsgeschichte des *Hynobius nebulosus*. Anat. Hefte, Vol. XL, pp. 193–283, pls. 13–16.

LIVINGSTON, B. E. and SHREVE, F.
1921 The Distribution of Vegetation in the United States, as Related to Climatic Conditions. Publ. Carnegie Inst., Washington, No. 284.

MILLER, NEWTON
1909 The American Toad (*Bufo lentigenosus americanus*. Le Conte). A Study in Dynamic Biology. Amer. Nat., Vol. XLIII, pp. 641–668.

MILLER, W. DE W.
1916 Notes on New Jersey Batrachians and Reptiles. Copeia, No. 34, pp. 67–68.

MOORE, J. PERCY
1894 Note on the Occurrence of *Hyla andersonii* in New Jersey, Amer. Nat., Vol. XXVIII, pp. 1045–1046.

NOBLE, G. K.
1922 The Phylogeny of the Salientia I. The Osteology and the Thigh Musculature; Their Bearing on Classification and Phylogeny. Bull. Amer. Mus. Nat. Hist., Vol. XLVI, pp. 1–87.
1923 A Contribution to the Herpetology of the Belgian Congo III, The Amphibia. (In press.)

OVERTON, FRANK
1914 Long Island Fauna and Flora, Vol. III, pp. 21–40, pls. 2–13.

PETERS, JOHN E.
1889 Another Specimen of *Hyla andersonii*. Amer. Nat., Vol. XXIII, pp. 58–59.

SHERWOOD, WILLIAM L.
1898 The Frogs and Toads Found in the Vicinity of New York City. Proc. Linnaean Soc. N. Y., pp. 9–24.

STONE, WITMER.
1901 Occurrence of *Hyla andersonii* at Clementon, N. J. Proc. Acad. Nat. Sci. Phila., Vol. LIII, p. 342.
1906 Notes on Reptiles and Batrachians of Pennsylvania, New Jersey and Delaware. Amer. Nat., Vol. XL, pp. 159–170.
1911 The Plants of Southern New Jersey, with Especial Reference to the Flora of the Pine-Barrens and the Geographic Distribution of the Species. Ann. Rept. N. J. State Museum for 1910, pp. 25–288, 120 pls.

THIELE, J.
1888 Der Haftapparat der Batrachierlarven. Zeitsch. f. Wiss. Zool., Vol. XLVI, pp. 67–79.

WELLMAN, G. B.
1917 Notes on the Breeding of the American Toad. Copeia, No. 51, pp. 107–108.

WRIGHT, A. H.
1914 North American Anura, Life Histories of the Anura of Ithaca, New York Publ. Carnegie Inst. Washington, No. 197.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

INDEX TO

VOLUME II-III

OCTOBER 1915-1923 AUGUST

NUMBERS 1-18 INCLUSIVE

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

1924

Index

INDEX

INDEX

INDEX

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 1

(Tropical Research Station Contribution Number 94)

1. OBJECTS OF THE TROPICAL RESEARCH STATION

By HENRY FAIRFIELD OSBORN,

President of the New York Zoological Society

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

SEPTEMBER, 1921

FIG 1 THE RESEARCH STATION AT KARTABO

OBJECTS OF THE TROPICAL RESEARCH STATION

By Henry Fairfield Osborn.

The main object of the Tropical Research Station from the beginning has been the *observation of living organisms in their natural environment.* To make this intensive and inclusive of the entire fauna, a single region has been selected and the fauna studied as a whole and in detail so far as possible through the expert knowledge of members of the staff and of the several experts who have been invited to work at the laboratory from time to time.

The work of the Station, therefore, is unique in two respects: First, its very intensive character; second, its restriction to a single locality on the border of a great zoological region, namely, the eastern tropical forests of the Amazonian basin. In many biological aspects it is new, in others it is the sequel to the long, distinguished period of exploration of this general region, beginning as early as 1812. The six best known explorers of eastern South America have been the following:

Charles Waterton, four voyages from 1812 to 1824, chiefly in Guiana.

Charles Darwin, 1832-1835, from Bahia around the entire South American coast to the Galapagos.

Alfred Russel Wallace, 1848-1852, the Amazon and Rio Negro.

Henry Walter Bates, 1848-1859, the Amazon basin from Para to Peru.

Thomas Belt, 1868, Nicaragua.

W. H. Hudson, born in Argentina seventy-odd years ago, and left for England about 1890.

To Waterton we owe the pioneer review of the life of this wonderful forest region; to Darwin, Wallace, Bates, and Belt the intimate relations of animals and plants with each other and with their environment, color and form adaptation, and struggle for existence; to Darwin and Hudson especially the complex chain of relations which connect the whole series of organisms together.

In the work of the Station it has been found absolutely necessary to lay a secure foundation in systematic zoology. For this purpose efforts are being made to complete and round out the faunal lists of various systematic workers in this region.

These lists will give a common language to the distinctive research feature of this Station, which, as remarked above, is intensive biologic observation in one region, in fact, in one locality, as distinguished from the observations of those who have covered and are covering the whole biologic field of South America.

The area chosen by our Honorary Curator of Birds, William Beebe, when he founded the Station in 1916, is the eastern edge of the tropical rain-forest of South America, which extends unbroken across the greater part of the continent. The fauna and flora are in general uniform with those of the entire Amazonian region. The locality at Kartabo, Bartica District, British Guiana, the point of junction of the Mazaruni and Cuyuni rivers, demonstrated in the first season its exceptional advantages as the site for a permanent station. Within ten minutes walk are sandy and rocky beaches, mangroves, grassland, swamp, and high jungle, each with a growth of life peculiar to itself. Free exposure to the trade winds, the absence of flies and mosquitos, invariably cool nights, excellent buildings assigned by the government—all these features contribute to the wide range of life and the unbroken health of the scientific staff. The work of the year 1916 was so full of promise that Mr. Beebe, then Curator of Birds of the New York Zoological Park, was promoted to the rank of Director of the Tropical Research Station and given entire charge both of the choice of the personnel and of the supervision of the scientific work.

The Station is now entering its sixth year. Owing to the difficulty of transportation at the time of the war, there was a

lapse during 1917, but work was resumed in 1918, continued in 1919, and the present VOLUME III of ZOOLOGICA opens the contributions of the year 1920-1921, which has proved to be the most productive of all.

The staff of specialists, artists and investigators has included in the course of the past six years the following persons:

WILLIAM BEEBE, *Director*, Columbia University and New York Zoological Society
General Evolutionary Problems in Ornithology and Ecology

IRVING W. BAILEY — Harvard University
Relations of Ants to Certain Plants

T. DONALD CARTER, *Collector*, New York Zoological Society

ISABEL COOPER, *Artist* — Bryn Mawr College

ALFRED EMERSON — Cornell University
Life Histories of Kartabo Termites

GERTRUDE EMERSON — University of Chicago
Anthropology

WINIFRED J. EMERSON, *Artist* — Cornell University

J. F. M. FLOYD — University of Glasgow
Parasites of Vertebrates

W. T. M. FORBES — Cornell University
Organs of Hearing in Lepidoptera

H. GIFFORD — University of Nebraska
Comparative Opthalmology

G. I. HARTLEY — Cornell University
Relationships of Certain Non-oscine Birds

RACHEL HARTLEY, *Artist* — New York

PAUL G. HOWES — Bruce Museum
Studies in Hymenoptera

GEORGE W. HUNTER — Carlton College
General Biology

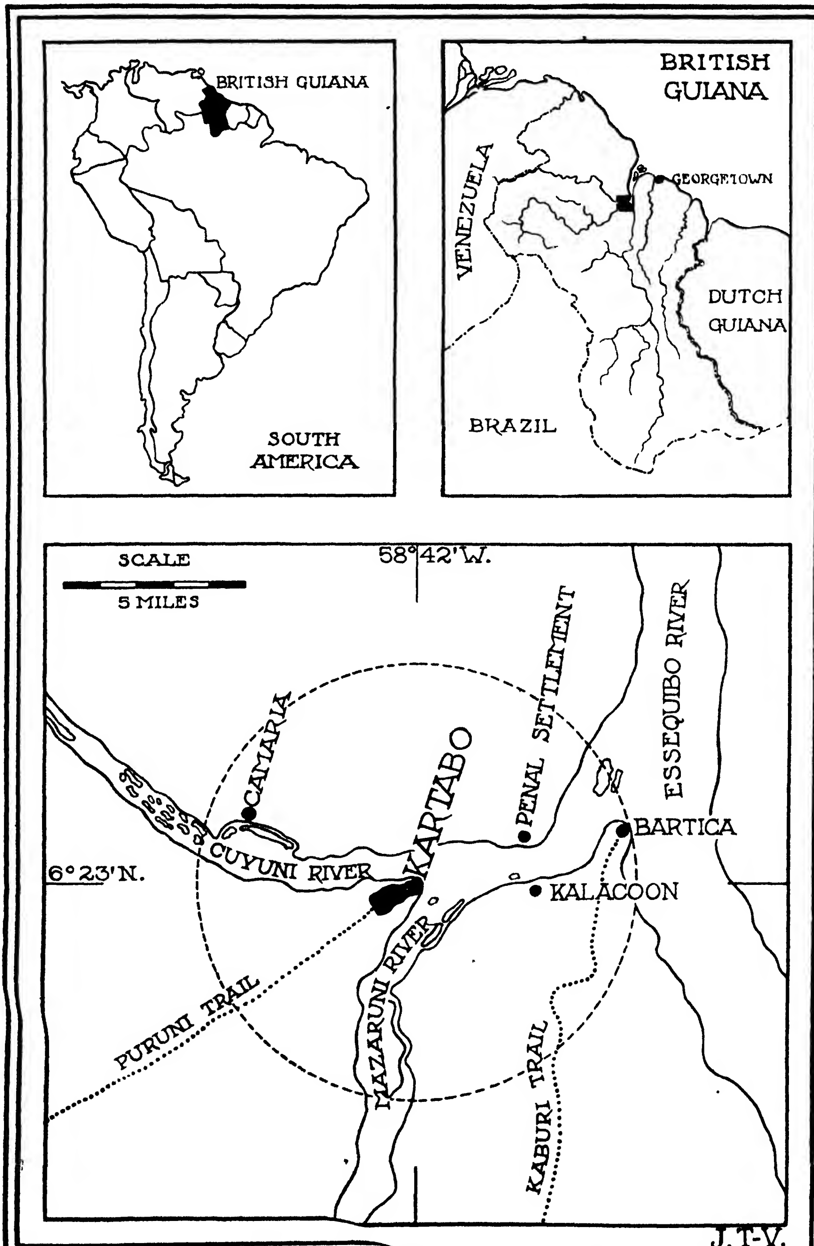


FIG. 2. LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of ... miles.

CLIFFORD POPE — University of Virginia
Life Histories of Kartabo Fish

ALBERT M. REESE — University of West Virginia
Embryology of Crocodiles and Investigation of Microscopical Beach Life

MABEL SATTERLEE — Columbia University
Coloration of *Ameiva* and Painting Optical Fundi

T. V. SMOLUCHA — New Jersey
Photography and Pen-and-Ink Drawing

ANNA TAYLOR — South Carolina
Botanical Paintings

JOHN TEE-VAN — New York Zoological Society
Ecology of Certain Lepidoptera

WM. MORTON WHEELER — Harvard University
Ants of Kartabo

C. A. WOOD — Leland Stanford University
Optical Fundi of Birds and Other Vertebrates

Ninety-three contributions have already been published from the Tropical Research Station, of which a complete annotated list is given in ZOOLOGICA III, No. 2. Of these eighty-nine are scientific papers and magazine articles, while four are included in the following bound volumes:

TROPICAL WILD LIFE IN BRITISH GUIANA, by Beebe, Hartley and Howes.

INSECT BEHAVIOR, by Paul G. Howes.

JUNGLE PEACE, by William Beebe.

EDGE OF THE JUNGLE, by William Beebe.

These published observations of the Station are so broad in scope that only a few salient features can be noted in this Introduction. They extend from color changes and adaptations to anatomical and physiological characters of the archaic forms of life, like the hoatzin, as well as of the most highly modernized and specialized forms. The colors of living amphibians and reptiles are almost an untouched field, since all modern systematic

zoology and description of these phyla have been founded on alcoholic specimens, in which the colors are either modified or lost altogether. It is only in the feathers of birds and in the coats of mammals that the natural color hues can be preserved. The paintings made directly from life by the artists of the Station, Miss Cooper and Miss Satterlee, will be published in a series of plate volumes accompanying the text volumes of ZOOLOGICA. The opportunity of studying the faunal and floral complex and the independent and interrelated adaptations in all grades of life, both in the vertical and in the horizontal life zones, opens up vistas for future research extending over many years. The vertical division of the fauna and flora into distinctive life zones, extending from the tree summits to the sub-soil, is a biologic contribution of first importance.

The Station was honored during the year 1920-1921 by the presence of Dr. Wm. Morton Wheeler, who makes an extremely important contribution to entomology in the present volume of ZOOLOGICA through his article on *A Study of Some Social Beetles in British Guiana and of Their Relations to the Ant-plant Tachigalia.*

Of the work of the Staff of the Research Station the following may be mentioned as having been accomplished to date:

Life History Notes on 445 species of birds, by Beebe and Hartley.

Life History Notes on 106 species of reptiles and amphibians, by Beebe.

One thousand five hundred and thirty-two photographic negatives, by Beebe, Howes, Tee-Van and Smolucha.

Ten thousand feet of moving picture film, by Tee-Van.

Collection of 340 water color drawings by Isabel Cooper.

Collection of types of 50 new species of termites.

Four hundred transparent preparations of embryos and tongues, etc.

Four hundred skeletons of mammals and birds.

Nests and eggs of 132 species of birds, many new to science.

Materials for a monograph on the syrinx and the voice of tropical birds.

Collection of 75,000 insects.

Collection of 776 bird skins.

Collection of 110 embryos of birds.

Materials for the study of the optical fundi of birds.

Monographic work on Trogons.

Cooperation with the Zoological Park, the Aquarium, the American Museum of Natural History, and Other Institutions

Besides the research work carried on at the Station there are three general lines of cooperation with other institutions. First, living organisms collected for the New York Zoological Park and the New York Aquarium, among which the most interesting forms are the following:

Birds

3 Cocks-of-the-Rock	*Rupicola rupicola* (Linné)
Hawk-headed Parrot	*Deroptyus accipitrinus accipitrinus* (Linné)
Imperial Amazon Parrot	*Amazona imperialis* (Richm.)
White-necked Rails	*Porzana albicollis* Vieill.
Bat Falcons	*Falco rufigularis rufigularis* Daud.
imThurn's Blackbird	*Agelaius imthurni* Sclater
Etc.	

Mammals

Silky Anteater	*Cyclopes didactylus didactylus* (Linné)
Tayra	*Tayra barbara barbara* (Linné)
2-toed Sloth	*Choloepus didactylus* (Linné)
3-toed Sloth	*Bradypus tridactylus* Linné
Spotted Cavy	*Agouti paca paca* (Linné)
Red Howling Monkey	*Alouatta seniculus macconnelli* Elliot
Jaguarondi	*Herpailurus jaguarondi unicolor* (Traill)
Wild Dog	*Cerdocyon thous thous* (Linné)
Etc.	

zoology and description of these phyla have been founded on alcoholic specimens, in which the colors are either modified or lost altogether. It is only in the feathers of birds and in the coats of mammals that the natural color hues can be preserved. The paintings made directly from life by the artists of the Station, Miss Cooper and Miss Satterlee, will be published in a series of plate volumes accompanying the text volumes of ZOOLOGICA. The opportunity of studying the faunal and floral complex and the independent and interrelated adaptations in all grades of life, both in the vertical and in the horizontal life zones, opens up vistas for future research extending over many years. The vertical division of the fauna and flora into distinctive life zones, extending from the tree summits to the sub-soil, is a biologic contribution of first importance.

The Station was honored during the year 1920-1921 by the presence of Dr. Wm. Morton Wheeler, who makes an extremely important contribution to entomology in the present volume of ZOOLOGICA through his article on *A Study of Some Social Beetles in British Guiana and of Their Relations to the Ant-plant Tachigalia.*

Of the work of the Staff of the Research Station the following may be mentioned as having been accomplished to date:

Life History Notes on 445 species of birds, by Beebe and Hartley.

Life History Notes on 106 species of reptiles and amphibians, by Beebe.

One thousand five hundred and thirty-two photographic negatives, by Beebe, Howes, Tee-Van and Smolucha.

Ten thousand feet of moving picture film, by Tee-Van.

Collection of 340 water color drawings by Isabel Cooper.

Collection of types of 50 new species of termites.

Four hundred transparent preparations of embryos and tongues, etc.

Four hundred skeletons of mammals and birds.

Nests and eggs of 132 species of birds, many new to science.

Materials for a monograph on the syrinx and the voice of tropical birds.

Collection of 75,000 insects.

Collection of 776 bird skins.

Collection of 110 embryos of birds.

Materials for the study of the optical fundi of birds.

Monographic work on Trogons.

Cooperation with the Zoological Park, the Aquarium, the American Museum of Natural History, and Other Institutions

Besides the research work carried on at the Station there are three general lines of cooperation with other institutions. First, living organisms collected for the New York Zoological Park and the New York Aquarium, among which the most interesting forms are the following:

Birds

3 Cocks-of-the-Rock	*Rupicola rupicola* (Linné)
Hawk-headed Parrot	*Deroptyus accipitrinus accipitrinus* (Linné)
Imperial Amazon Parrot	*Amazona imperialis* (Richm.)
White-necked Rails	*Porzana albicollis* Vieill.
Bat Falcons	*Falco rufigularis rufigularis* Daud.
imThurn's Blackbird	*Agelaius imthurni* Sclater
Etc.	

Mammals

Silky Anteater	*Cyclopes didactylus didactylus* (Linné)
Tayra	*Tayra barbara barbara* (Linné)
2-toed Sloth	*Choloepus didactylus* (Linné)
3-toed Sloth	*Bradypus tridactylus* Linné
Spotted Cavy	*Agouti paca paca* (Linné)
Red Howling Monkey	*Alouatta seniculus macconnelli* Elliot
Jaguarondi	*Herpailurus jaguarondi unicolor* (Traill)
Wild Dog	*Cerdocyon thous thous* (Linné)
Etc.	

Reptiles

8-foot Bushmaster	*Lachesis mutus* (Linné)
Iguanas	*Iguana iguana* (Linné)
White Amphisbena	*Amphisbena alba* Linné
Black and White Amphisbena	*Amphisbena fuliginosa* Linné
5 Crocodiles	*Caiman sclerops* (Schneid.)
Etc.	

Amphibians

Marine Toads	*Bufo marinus* (Linné)
Five-fingered Jungle Frog	*Leptodactylus pentadactylus* (Laur.)
Sharp-nosed Toad	*Bufo typhonius* (Linné)
Harlequin Frogs	*Dendrobates* sp.
Etc.	

Fish

Electric Eels	*Electrophorus electricus* (Linné)
Marbled Eel	*Symbranchus marmoratus* Bloch.
Perai	*Pygocentrus niger* (Schomb.)
Etc.	

Second, for the American Museum of Natural History, there has been brought together a collection of 485 mammals belonging to numerous species, preserved with their skins, skulls and skeletons. Many of these mammals are of especial interest because of the fact that most of the South American types of the great Swedish naturalist Linnaeus were brought originally from this region of the continent. Alcoholic collections of several hundred reptiles, amphibians and fish have been made, preserved, labeled, and shipped to the American museum.

Third, of especial significance is the collection of photographic and botanical material which, together with the actual specimens themselves, has been gathered and furnished to the Museum for large groups of Red Howling Monkeys, *Alouatta seniculus macconnelli* Elliot, and Hoatzin, *Opisthocomus hoazin* (P. L. S. Mull.).

Other institutions have been aided as follows: (1) Specimens have been supplied to the Embryological Laboratories of the Carnegie Institution at Johns Hopkins University, for study of the embryology of the Red Howling Monkey; (2) numerous electric eels have been captured and sent to Dr. Ulric Dahl-

gren at Princeton University, for investigation of the electric organs of these animals; (3) a large collection of birds in alcohol has been made for Dr. C. A. Wood, for future study, at Leland Stanford University, of the various structures of the eye.

ZOOLOGICAL SOCIETY, New York, July 12, 1921.

FIG 3 THE MAZARUNI RIVER
Looking east from the Research Station at Kartabo

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 2

(Tropical Research Station Contribution Number 95)

2. CONTRIBUTIONS OF THE TROPICAL RESEARCH STATION, 1916 TO 1921

By WILLIAM BEEBE,

Director of the Tropical Research Station and Honorary Curator of Birds

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

SEPTEMBER, 1921

CONTRIBUTIONS
OF THE
TROPICAL RESEARCH STATION
OF THE
NEW YORK ZOOLOGICAL SOCIETY

By William Beebe.

From the date of the establishment of the Tropical Research Station in January, 1916, to September, 1921, there have been published ninety-three contributions. Of these, eighty-nine are scientific papers or magazine articles and four bound volumes. To correlate, in convenient form, these contributions with the more important facts set forth in them, I have prepared the following list:

1916

Contribution Number

1. ESTABLISHMENT OF THE TROPICAL RESEARCH STATION
   William Beebe
   Bull. Zool. Soc. XIX, No. 4, July, p. 1369
   Hints for the formation of a tropical station, and photographs of jungle and laboratory.

2. NOOSING A BUSHMASTER
   William Beebe
   Ibid, p. 1372
   Method of capturing an eight-foot venomous snake alive and unharmed. *Lachesis mutus* (Linné)

3. THE COCK-OF-THE-ROCK
   Lee S. Crandall
   Ibid, p. 1375
   Habits of the bird, wild and in captivity. *Rupicola rupicola* (Linné).

4. NESTLING HOATZINS AT HOME
   William Beebe
   Bull. Zool. Soc. XIX, No. 5, Sept., p. 1393
   Thorough account of the activities and psychology of hoatzin chicks, photographs of the chicks climbing and in the nest, adult on nest, nest and eggs, and general environment. *Opisthocomus hoazin* (P.L.S. Mull.)

5. PICTURES FROM THE TROPICAL RESEARCH STATION
   WILLIAM BEEBE and PAUL G. HOWES
   Ibid, p. 1400
   Photographs of
   House Bats, *Vampyrus* sp.,
   Beesa Monkey, *Pithecia pithecia* (Linné)
   Aracari Toucan, *Pteroglossus aracari atricollis* (P.L.S. Mull.) and Akawai Indian Benab.

6. WASPS AT THE TROPICAL RESEARCH STATION
   PAUL G. HOWES
   Ibid, p. 1412
   Brief account of wasp life at the Station. Photographs of the insects and their nests.

7. NOTES ON THE PERAI
   G. INNESS HARTLEY
   Bull. Zool. Soc. XIX, No. 6, p. 1428
   Description, habits and methods of capture, photographs of teeth and entire fish, *Serrasalmo niger* (Schomb.).

8. A JUNGLE-BOUND RESEARCH STATION
   WILLIAM BEEBE and PAUL G. HOWES
   New York Tribune, Photogravure Section, December 24th, p. 3
   Photographs of
   Trumpeter Chicks, *Psophia crepitans* Linné
   Rhinoceros Beetle Grub, *Megasoma actacon* Linné
   House Bats, *Hemiderma p. perspicillatum* (Linné)
   Beesa Monkey, *Pithecia pithecia* (Linné)
   Young Aracari Toucan, *Pteroglossus aracari atricollis* (P.L.S. Mull.)
   Young Hoatzins, *Opisthocomus hoazin* (P.L.S. Mull.)
   Perai, *Serrosalmo niger* (Schomb.)
   Giant Tree Frog, *Hyla maxima* (Laur.).

9. ANNUAL REPORT TO THE ZOOLOGICAL SOCIETY
   Annual Report, New York Zool. Soc., 1916, p. 113
   Résumé of first season's work at the Station, with personal contributions; photographs of laboratory.

1917

10. THE ALLIGATORS OF GEORGETOWN
    WILLIAM BEEBE
    Bull. Zool. Soc. XX, No. 1, p. 1437
    Life history, breeding habits, method of capture, variation of young, photographs, drawings of young, *Caiman sclerops* (Schneid.).

11. INTERESTING BIRD'S NESTS FROM SOUTH AMERICA

WILLIAM BEEBE and PAUL G. HOWES

Ibid., p. 1458

Folio of photographs of Bird's Nests from the Station. Cayenne Hermit Hummingbird, *Phoethornis superciliosus superciliosus* Linné
Guiana Pygmy Flycatcher, *Tyranniscus acer* (Salv. and God.)
Oily Flycatcher, *Pipramorpha oleaginea oleaginea* (Licht.).

12. THE POMEROON TRAIL

WILLIAM BEEBE

Atlantic Monthly, January

Note on distribution of opossums, reptiles, insects and seeds by floating logs and currents; account of a road newly built from the sea through a tropical jungle; bird life of rice-fields.

13. A NATURALIST'S TROPICAL LABORATORY

THEODORE ROOSEVELT

Scribner's, January, p. 46.

Detailed account of the founding, the operation and the environment of the Research Station, and of jungle life as observed on walks. Photographs of jungle, Indian huts, bats, *Phyllostomus h. hastatus* (Pallas), Nestling Parrots, *Pionus fuscus* (P.L.S. Mull.), and Mouse Opossum, *Marmosa murina murina* (Linné).

14 TROPICAL WILD LIFE IN BRITISH GUIANA

WILLIAM BEEBE, G. INNESS HARTLEY and PAUL G. HOWES, with introduction by THEODORE ROOSEVELT

Published by New York Zool. Soc.

General and detailed account of the first year's work of the Station. 143 photographs by William Beebe and Paul G. Howes. This volume contains contributions 15 to 50, which are reviewed under their respective numbers.

15. INTRODUCTION TO TROPICAL WILD LIFE IN BRITISH GUIANA

THEODORE ROOSEVELT

Introduction, p. ix.

Character of the work accomplished at a static research station in the tropics.

16. ESTABLISHMENT OF THE TROPICAL RESEARCH STATION

WILLIAM BEEBE

Chap. I, p. 23

Detailed account of the conception and establishment of the Research Station at Kalacoon, on the Mazaruni River, British Guiana. Map and photographs of the Station.

17. HISTORICAL BARTICA
    William Beebe
    Chap. II, p. 31
    History of three hundred years of occupation by the Spanish and Dutch.

18. THE NATURALISTS OF BARTICA DISTRICT
    William Beebe
    Chap. III, p. 38
    Brief account of the work of Schomburgk, Hilhouse, Appun, Lloyd, imThurn, Whitely and McConnell.

19. THE GENERAL FIELD OF WORK
    William Beebe
    Chap. IV, p. 43
    General surroundings and geology; map and photographs of the country.

20. THE OPEN CLEARING AND SECOND-GROWTH
    William Beebe
    Chap. V, p. 51
    Succession of plant communities consequent upon clearing primitive jungle and a subsequent four years' second growth. Birds inhabiting the various areas.

21. THE JUNGLE AND ITS LIFE
    William Beebe
    Chap. VI, p. 69
    Temperature and lack of dangers in jungle; seasons; vertical life zones of the jungle, with detailed distribution of birds and mammals.

22. THE BIRD LIFE OF BARTICA DISTRICT
    William Beebe
    Chap. VII, p. 91
    Comparison of temperate with tropical avifauna; daily and seasonal migrations; roosting habits; northern migrants; classification of birds as to sociability, voice, coloration, food, friends, enemies; relations to the Indians; legal protection of wild birds in British Guiana; collecting for the Zoological Park.

23. LIST OF THE BIRDS OF BARTICA DISTRICT
    William Beebe
    Chap. VIII, p. 127
    Classified list of 350 species of birds. By a proof-reading error on the part of one of the authors, the 22 starred species were made to read as new to the Colony of British Guiana, instead

of new to Brabourne and Chubb's List of the Birds of South America, the error being more absurd because some are among the most abundant species. This slip was deservedly corrected in a detailed article by Thomas E. Penard, (Auk, Vol. 36, No. 2, p. 217.)

24. AKAWAI INDIAN AND COLONIAL NAMES OF BIRDS AND MAMMALS

William Beebe

Chap. IX, p. 138

Akawai names of 143 species of birds and 41 species of mammals, taken orally, and after reconfirmation, transcribed.

25. METHODS OF RESEARCH

William Beebe

Chap. X, p. 147

Methods of shooting, trapping, or otherwise collecting and observing tropical organisms.

26. FURTHER NOTES ON THE LIFE HISTORY OF HOATZINS

William Beebe

Chap. XI, p. 155

Life History Notes of the Hoatzin, *Opisthocomus hoazin* (P.L.S. Mull.), in addition to those presented in "Ecology of the Hoatzin," Zoologica, Vol. I, No. 2, 1909, pp. 45-66. Photographs of environment, birds, nests and eggs.

27. THE HOMES OF TOUCANS

William Beebe

Chap. XII, p. 183

Detailed account of discovery of breeding habits of five species of Toucans, Red-billed Toucan, *Ramphastos monilis* Muller, Sulphur-and-white-breasted Toucan, *Ramphastos vitellinus* Licht., Black-necked Aracari, *Pteroglossus aracari atricollis* (P.L.S. Mull.), Green Aracari, *Pteroglossus viridis* (Linné), and the Guiana Toucanet, *Selenidera culik* (Wagler). Record and description of eggs of *Ramphastos monilis*, and of young *Pteroglossus aracari atricollis*. Photographs of nesting sites, eggs, young; diagrams of heel-pads of Black-necked Aracari.

28. ORNITHOLOGICAL DISCOVERIES

William Beebe

Chap. XIII, p. 213

Detailed description of nests and eggs of seventeen species of tropical birds which "have not heretofore been described, or are almost unknown." (For critical discussion of this paper, see Thomas E. Penard, Auk, Vol. 36, No. 2, p. 221).

Talpacoti Ground Dove *Chaemepelia talpacoti* (Temm. and Knip.), Red Mountain Dove *Oreopelia montana* (Linné), White-necked Crake, *Porzana albicollis* (Vieill.), Cayenne Crake, *Creciscus viridis viridis* (P.L.S. Mull.), Dusky Nighthawk, *Caprimulgus nigrescens* Cab., Guiana Tyrantlet, *Tyranniscus acer* (Salv. and God.), Oily Flycatcher, *Pipramorpha oleaginea oleaginea* (Licht.), Varied Flycatcher, *Empidonomus varius varius* (Vieill.), Cinereous Bushbird, *Thamnomanes glaucus* Cab., Rufus-fronted Antcatcher, *Anoplops rufigula rufigula* (Bodd.), Quadrille Bird, *Leucolepia musica musica* (Bodd.), Orange-headed Manakin, *Pipra aureola aureola* (Linné), Brown-breasted Pygmy Grosbeak, *Oryzoborus angolensis brevirostris* (Berlepsch), Chestnut-bellied Seedeater, *Sporophila castaneiventris* Cab., Black-headed Seedeater, *Sporophila bouvronides* (Less.), Blue Honey Creeper, *Cyanerpes cyaneus cyaneus* (Linné), and the Moriche Oriole, *Icterus chrysocephalus* (Linné). Photographs of nests.

29. YOUNG GREY-BACKED TRUMPETERS

WILLIAM BEEBE

Chapter XIV, p. 247

Detailed description of appearance, molt and habits of young Trumpeter, *Psophia crepitans* Linné, with photographs and colored plate.

30. THE WAYS OF TINAMOU

WILLIAM BEEBE

Chap. XV, p. 253

Life histories, nests, eggs and general account of Guiana Great Tinamou, *Tinamus major major* (Gmel.), Pileated Tinamou, *Crypturus soui soui* (Hermann), and the Variegated Tinamou, *Crypturus variegatus variegatus* (Gmel.), with photographs.

31. WILD LIFE NEAR KALACOON

WILLIAM BEEBE

Chap. XVI, p. 271

Detailed account of awakening of tropical wild life from 5.30 to 6.45 A.M., on mornings of March 26, May 16 and July 2nd, 1916. Log of occurrences, broods, migrations and nesting seasons of tropical organisms, from June 15th to August 16th.

32. THE ALLIGATORS OF GEORGETOWN

WILLIAM BEEBE

Chap. XVII, p. 283

Detailed account of life history, breeding habits, eggs, young, variation in young, photographs and diagrams of young. *Caiman sclerops* (Schneid.).

33. NOTES ON THE DEVELOPMENT OF THE JACANA

G. INNESS HARTLEY

Chap. XVIII, p. 293

General development, pterylosis, head of embryo, toes and claws, spurs, relationships of growing leg and wing to body. With diagrams of wing growth, of legs and wings compared to body and of ontogenetic variations. Photograph of spurs. *Jacana jacana jacana* (Linné).

34. NOTES ON THE DEVELOPMENT OF THE SMOOTH-BILLED ANI

G. INNESS HARTLEY

Chap. XIX, p. 307

Detailed description of pterylosis of embryo and adult, wing pads, development of wing, bones of leg, and development of bill. With diagrams, charts, and photograph of embryo. *Crotophaga ani* (Gmel.).

35. NOTES ON A FEW EMBRYOS

G. INNESS HARTLEY

Chap. XX, p. 321

Pterylosis and external characters of embryos of *Caprimulgus nigrescens* Cab., *Pitangus sulphuratus sulphuratus* (Linné), and *Empidonomus varius varius* (Vieill.).

36. NESTING HABITS OF THE GREY-BREASTED MARTIN

G. INNESS HARTLEY

Chap. XXI, p. 328

Breeding season, courtship, nest-building, eggs, young, food, development of flight, and instincts of young birds. Photograph of young. *Progne chalybea chalybea* (Gmel.).

37. PRELIMINARY NOTES ON THE DEVELOPMENT OF THE WING

G. INNESS HARTLEY

Chap. XXII, p. 342

Development of the wing and pinion in relation to habits of *Opisthocomus hoazin* (P. L. S. Mull.), *Psittacula passerina* (Linné), *Psophia crepitans* Linné, *Butorides striata* (Linné), *Pteroglossus aracari atricollis* (P.L.S. Mull.), *Galeoscoptes carolinensis* (Linné), *Cacicus cela cela* (Linné), *Pitangus sulphuratus sulphuratus* (Linne), and *Progne chalybea chalybea* (Gmel.). Development of the pinion of the following species: *Opisthocomus hoazin* (P. L. S. Mull.), *Psophia crepitans* Linné, *Pitangus sulphuratus sulphuratus* (Linné), *Pteroglossus aracari atricollis* (P. L. S. Mull.), *Galeoscoptes carolinensis* (Linné), *Progne chalybea chalybea* (Gmel.).

38. NOTES ON THE PERAI FISH

G. INNESS HARTLEY

Chap. XXIII, p. 342

A general account of this dangerous fish elaborated from contribution number 7.

39. THE BEES AND WASPS OF BARTICA

PAUL G. HOWES

Chap. XXIV, p. 371

General account, relation of rainfall to nesting, difficulties in rearing larvae.

40. TWO POTTER WASPS

PAUL G. HOWES

Chap. XXV, p. 376

General account, nests, food of young, egg, larva, cocoon, pupation. Red Potter Wasp *Eumenes canaliculata*, and Buff Eumenes, *Eumenes*, sp. Colored plates of egg, larva, pupa and imago. Photographs of wasp on nest, nests, and of larva within the nests.

41. LARVAL SACRIFICE

PAUL G. HOWES

Chap. XXVI, p. 386

Life history, nest, eggs, discussion of transformation from larva to pupa and imago. Colored plate of egg, larva, pupa and imago, Figure 125—9, 10, 11 and 12. Photographs of pupa, and of transformation from larva to pupa. *Podium rufipes* (Fabr.).

42. THE BLACK REED WASP

PAUL G. HOWES

Chap. XXVII, p. 394

Nests, nesting, nest provisions, egg, larva, pupa, method of depositing eggs in chambers of nest. Colored plate of egg, larva, pupa and imago, Figure 125—13, 14, 15 and 16. Photographs of nests. *Trypoxylon cinereohirtum* Cam.

43. THE WHITE-FOOTED WASP

PAUL G. HOWES

Chap. XXVIII, p. 401

General account, method of laying eggs, larval food, nests, eggs, larva, cocoon, pupa, emergence. Colored plate of egg, larva, pupa and imago, Figure 133—1, 2, 3 and 4. Photograph of cocoon. *Trypoxylon leucotrichium* Rohmer.

44. THE FOREST SHELL WASP

PAUL G. HOWES

Chap. XXIX, p. 407

General account, nests, egg, larval food, larva, artificial feeding of larva, pupation, emergence. Colored plate of egg, larva, pupa and imago, Figure 133—5, 6, 7 and 8. Photographs of nests and larvae. *Zethusculus hamatus* Zav.

45. THE ONE-BANDED DAUBER

PAUL G. HOWES

Chap. XXX, p. 413

General account, methods of constructing nests, discussion of sense of direction, larval food, egg, larva, pupa, cocoon. Colored plate, Figure 133—9, 10, 11 and 12. Photographs of nest, wasp at nest and newly emerged specimen. *Sceliphron fistulare* Dahlb.

46. THE BLUE HUNTRESS

PAUL G. HOWES

Chap. XXXI, p. 413

General account, nest, larval food, egg, larvae, pupa, emergence from cocoon. Colored plate, egg, larva, pupa and imago, Figure 133—13, 14, 15 and 16. Photographs of wasp at nest, cocoon. *Chlorion neotropicus* Kohl.

47. PARALYZED PROVENDER

PAUL G. HOWES

Chap. XXXII, p. 436

General account of the actions of wasps in paralyzing spiders and insects. Forms of paralysis produced by wasps.

48. CONTROLLED PUPATION

PAUL G. HOWES

Chap. XXXIII, p. 443

General account of larva of Trypetid flies of genus *Spilographa*. Transformation of larva to pupa. Photographs of larva.

49. NOTES FROM THE HINTERLAND OF GUIANA

WALTER G. WHITE

Chap. XXXIV, p. 453

General account of the country and the animals found along the upper Rupununni River.

50. INDIAN CHARMS

JAMES RODWAY

Chap. XXXV, p. 488

Charms and superstitions of the Guiana Indians, with colored plate of plant leaves used as charms.

51. A HUNT FOR HOATZINS

William Beebe

Atlantic Monthly, February.

Detailed account of the general environment of hoatzins. *Opisthocomus hoazin* (P. L. S. Mull.).

52. WITH ARMY ANTS SOMEWHERE IN THE JUNGLE

William Beebe

Atlantic Monthly, April

Method of attack, securing and carrying food, and general account of the offensive activities of *Eciton burchelli* Westwood.

53. A WILDERNESS LABORATORY

William Beebe

Atlantic Monthly, May

Method of founding and operating a jungle laboratory with description of the environment, opportunities for research, servants, etc.

54. COLONEL ROOSEVELT AND THE TROPICAL RESEARCH STATION

William Beebe

Timehri (3), IV, June, p. 27

Brief narrative of the part which Colonel Roosevelt played in the conception and development of the Station.

55. JUNGLE NIGHT

William Beebe

Atlantic Monthly, July

Activities of organisms on moonlit nights in the Guiana jungle.

56. ANNUAL REPORT OF THE TROPICAL RESEARCH STATION

William Beebe

Annual Report of the New York Zool. Soc. 1917, p. 99

Activities of the Station staff during the year 1917.

1918

57. A SILKY EATER OF ANTS

William Beebe

Bull. Zool. Soc. XXI, No. 1, January, p. 1561

General account of the Silky Anteater, *Cyclopes didactylus didactylus* (Linné), with photographs and drawings.

58. LABEL-MAKING IN THE FIELD

WILLIAM BEEBE

Ibid., p. 1574

Short account of simple photographic method of making field labels of small size.

59. A SECOND IMPERIAL PARROT

WILLIAM BEEBE

Ibid., p. 1578

General account of the second specimen of this rare parrot brought to the Zoological Park, *Amazona imperialis* (Rich.).

60. INSECT TYRANTS

WILLIAM BEEBE

Bull. Zool. Soc. XXI, No. 5, p. 1670

General account of the methods of attack, and methods of transportation used by the army ant, *Eciton burchelli* Westwood. With two drawings.

61. ANTS COLLECTED IN BRITISH GUIANA BY MR. WILLIAM BEEBE

WILLIAM MORTON WHEELER

Jour. N. Y. Ento. Soc., Vol. XXVI, No. 1, March, p. 23

Account of a small collection of ants taken from twenty square feet of bushes at Penal Settlement, Bartica District. The collection comprises 42 forms and the following new species:

Camponotus (*Myrmobrachys*) *beebei* Wheeler.
Crematogaster ornatipilis Wheeler.

62. ISLANDS

WILLIAM BEEBE

Jour. Am. Mus. Nat. Hist., Vol. XVIII, No. 6, p. 453

Notes on the West Indies, from St. Thomas to Barbados.

63. CONVICT TRAIL

WILLIAM BEEBE

Atlantic Monthly, September

The cutting of a trail through second growth jungle and the subsequent effect on flora and fauna; social sleeping habits of Ithomiid and Heliconid butterflies.

64. SEA WRACK

WILLIAM BEEBE

Atlantic Monthly, October.

Study of the pelagic life and sargossa weed organisms between New York and British Guiana.

65. JUNGLE PEACE

William Beebe

8vo., New York, Henry Holt & Co. Illustrated by the author.
Collection in book form of contributions 12, 51, 52, 53, 55, 62, 63 and 64.

66. BEES FROM BRITISH GUIANA

T. D. A. Cockerell

Bull. Amer. Mus. Nat. Hist., Vol. XXXVIII, Art. XX, p. 685
Account of a small collection of bees from Bartica District, with key to all the forms in the collection, and descriptions of the following new species and varieties:

Euglossa decorata Smith, var. *ruficauda* Cockerell
Euglossa ignita Smith, var. *chlorosoma* Cockerell
Epicharis maculata var. *barticana* Cockerell
Rhathymus beebei Cockerell
Augochlora callichlorura Cockerell
Florilegus barticanus Cockerell

Included in this paper is a description of a new species from French Guiana in the author's collection:

Augochlora maroniana Cockerell.

67. ANNUAL REPORT OF THE TROPICAL RESEARCH STATION

William Beebe

Annual Report N. Y. Zool. Soc., 1918, p. 84
Activities of the Station during 1918.

1919

68. REVIEW OF "TROPICAL WILD LIFE IN BRITISH GUIANA"

George W. Hunter

Bull. Zool. Soc., XXII, No. 1, p. 21
Critical and detailed review of the work of the Tropical Research Station as narrated in "Tropical Wild Life in British Guiana."

69. HAMMOCK NIGHTS

William Beebe

Atlantic Monthly, February
Night life of the jungle as observed from a hammock.

70. HIGHER VERTEBRATES OF BRITISH GUIANA, LIST OF AMPHIBIA, REPTILIA AND MAMMALIA

William Beebe

Zoologica, Vol. II, No. 7, p. 205
Check list of 52 amphibians, 112 reptiles and 119 mammals of British Guiana of which almost half occur at the Station.

(See in connection with this paper, "Comments on a Recent Check-list," by Thomas Barbour, American Naturalist, Vol. LIV, page 285.)

71. BIRDS OF BARTICA DISTRICT

William Beebe

Zoologica, Vol. II, No. 8, p. 229

Check list of 75 birds new to the Bartica District. This list is a supplement to the list found in Contribution 23.

72. LIZARDS OF THE GENUS *AMEIVA*

William Beebe

Zoologica, Vol. II, No. 9, p. 235

A brief, critical study of the pattern and color of *Ameiva* lizards, with a discussion of Barbour and Noble's paper, "A Revision of the Lizards of the Genus *Ameiva*," Bull. Mus. Comp. Zool., Harvard, LIX, No. 6, 1915, pp. 417-479.

73. THE TROPICAL RESEARCH STATION

William Beebe

Bull. Zool. Soc., XXII, No. 4, p. 274

Brief account of the re-establishment of the Tropical Research Station at its new home, Kartabo, with short account of some of the forms of life at the Station.

74. THE TERMITES OF KARTABO

Alfred Emerson

Ibid., p. 75

Notes on termite nests and general termite ecology.

75. A HOME TOWN OF THE ARMY ANTS

William Beebe

Atlantic Monthly, October

Detailed account of the temporary nest and the intricate nest activities of a colony of *Eciton burchelli* Westwood.

76. INSECT BEHAVIOR

Paul G. Howes

Richard G. Badger, Boston, Mass.

Chapters II to IX, inclusive, are reprints of contributions 41 to 48 from "Tropical Wild Life."

77. ANNUAL REPORT OF THE TROPICAL RESEARCH STATION

William Beebe

Annual Report, N. Y. Zool. Soc. 1919, p. 115.

Activities of the Station for the year 1919.

1920

78. A JUNGLE CLEARING

William Beebe

Atlantic Monthly, January

Comparison of superficial aspects of tropical with temperate fauna and flora; biocoenose of a weed, parrakeets, cotingas and toucans.

79. THE LURE OF KARTABO

William Beebe

Atlantic Monthly, February

The founding of the Station at its permanent site, and description of the wild life in the immediate vicinity.

80. TROPICAL TADPOLES

John Tee-Van

Bull. Zool. Soc., Vol. XXIII, No. 1, Jan., p. 9

Brief account of tadpoles and tadpole habits at Kartabo.

81. FOURTH YEAR OF THE NEOTROPICAL RESEARCH STATION

Henry Fairfield Osborn

Science, June 11, 1920, pages 585-587

Résumé of the foundation, objects and achievements of the Station.

82. ANNUAL REPORT OF THE TROPICAL RESEARCH STATION

William Beebe

Annual Report, N. Y. Zool. Soc. 1920, p. 111.

Activities of the Station during 1920.

1921

83. A TROPIC GARDEN

William Beebe

Atlantic Monthly, February

Habits of manatees, *Trichechus manatus* Linné, jacanas, *Jacana jacana jacana* (Linné), mongoose, *Mungos mungo* (Gmelin), and herons.

84. GUINEVERE THE MYSTERIOUS

William Beebe

Atlantic Monthly, March

Phyllomedusa bicolor (Bodd.), its environment, metamorphosis and habits.

85. A NEW CASE OF PARABIOSIS AND THE "ANT GARDENS" OF BRITISH GUIANA

WILLIAM MORTON WHEELER

Ecology, Vol. II, No. 2, April, 1921, p. 89

Résumé of the known cases of myrmicine parabiosis. Records of the parabiosis of *Camponotus* and *Crematogaster* in 80 per cent of the ant gardens found near the Station; detailed account of these gardens.

86. THE BAY OF BUTTERFLIES

WILLIAM BEEBE

Harpers Magazine, April

Habits of the Giant Singing Catfish, *Doras granulosus* Valenciennes; the Long-armed Beetle, *Acrocinus longimanus* (Linné), and general life of the tidal area of the Mazaruni shore; migration and social habits of five species of *Catopsilia.*

87. A JUNGLE BEACH

WILLIAM BEEBE

Atlantic Monthly, May

The ecological results, floral and faunal, of the falling of a single tree into the water; organisms living in the tide-washed roots of trees.

88. OBSERVATIONS ON ARMY ANTS IN BRITISH GUIANA

WILLIAM MORTON WHEELER

Proc. Am. Acad. Arts and Sci., Vol. 56, No. 8, June 1921, p. 291

Notes on the life histories of twelve species of army-ants, three of which are new to science; description of the female of *Eciton burchelli* Westwood, and the males of that species and of *Eciton pilosum* F. Smith. Descriptions of the following new species and varieties: *Eciton (Acamatus) angustinode* Emery subsp. *emersoni* Wheeler, *Eciton (Labidus) praedator* F. Smith var. *guianense* Wheeler, *Eciton (Acamatus) pilosum* F. Smith var. *beebei* Wheeler, and *Cheliomyrmex megalonyx* Wheeler. With many photographs and drawings.

89. THE GARDENS OF THE JUNGLE

WILLIAM BEEBE

House and Garden Magazine, July

An account of the plants raised by the Akawai Indians of Guiana.

90. THE ATTAS—A JUNGLE LABOR UNION

WILLIAM BEEBE

Atlantic Monthly, July

Atta cephalotes Fab. Foundation of the nest by the queen, leaf cutting activities, the trails, functions of the minims in the field, and abnormal actions of the maxims.

91. THE ATTAS AT HOME

WILLIAM BEEBE

Atta cephalotes Fab. The nest, its appearance, environment, visitors, parasitic and otherwise, reactions in defense, fungus gardens, habits of the parasitic cockroach *Attaphila*, marriage flight of the males and females, founding of a new colony.

92. SEQUELS

WILLIAM BEEBE

Atlantic Monthly, October

Instrumental sounds made by Tapping Wasp, *Synoeca irina* Spinola; voice of *Trogonurus curucui curucui* (Linné); remarkable exhibition of instinct by *Eciton burchelli* Westwood, an entire colony being confined to a one-hundred yard circle for several days.

93. EDGE OF THE JUNGLE

WILLIAM BEEBE

8vo. Henry Holt & Co., New York, October

Collection in book form of contributions Nos. 69, 75, 78, 79, 83, 84, 86, 87, 89, 90, 91, 92.

APPENDIX

Before the establishment of the Tropical Research Station there were published in the first and second volumes of ZOOLOGICA a number of articles by William Beebe, then Curator of Birds, dealing with Neotropical zoology. In order to correlate all the past work of the Society in this direction a list of titles is presented:

A CONTRIBUTION TO THE ECOLOGY OF THE ADULT HOATZIN

WILLIAM BEEBE

Zoologica, I, No. 2, 1909, p. 45

History, names, distribution, general appearance, parasites, food, nests, eggs, enemies and odors. Field notes on this species made in British Guiana and Venezuela. Methods of photographing. Bibliography, map of distribution and photographs of the adults in their natural surroundings. *Opisthocomus hoazin* (P. L. S. Mull.).

AN ORNITHOLOGICAL RECONNAISSANCE OF NORTHEASTERN VENEZUELA

WILLIAM BEEBE

Zoologica, I, No. 3, 1909, p. 67

General character of the pure mangrove forest, the mainland forest and the pitch lakes. Annotated list of the birds observed, and ecological conclusions concerning the birds of the Orinoco region. Notes on the voice of many species of birds. Descriptions of the nests and eggs of the following species: Great Blue Tinamou, *Tinamus tao* Temm., Venezuelan Rufous-tailed Jacamar, *Galbula ruficauda* Cuv., Yellow-backed Cassique, *Caccicus persicus* Linné, and the eggs and young of the Yellow-fronted Amazon Parrot, *Amazona ochrocephala* (Gmel.).

NEW SPECIES OF INSECTS COLLECTED BY C. WILLIAM BEEBE IN SOUTH AMERICA

Zoologica, I, No. 4, 1910, p. 118

Descriptions of the following new genera and species of insects collected by William Beebe in British Guiana and Venezuela:

MALLOPHAGA

Colpocephalum armiferum Kellogg—host *Opisthocomus hoazin* (P. L. S. Mull.); *Lipeurus absitus* Kellogg—same host. Described by Vernon L. Kellogg, Stanford University, California.

ORTHOPTERA

Stagmomantis hoorie Caudell. Described from male and female specimens from near the Hoorie gold mine on Hoorie Creek, a tributary of the Barama River, British Guiana, by A. N. Caudell, U. S. National Museum, Washington, D. C.

LEPIDOPTERA

The following new species and genera were described by Harrison G. Dyar, U. S. National Museum, Washington, D. C.: *Hylesia indurata*, *Zatrephes cardytera*, genus *Zaevius*, *Zaevius calocore*, genus *Thyonaea*, *Thyonaea dremma*, *Illice biota*, *Neophaenis acdemon*, *Emarginea empyra*, *Hadena niphetodes*, *Capnodes albicosta*, *Thermesia dorsilinea*, *Claphe laudissima*, *Rifargia phanerostigma*, *Eois costalis*, the female of *Racheolopha nivetacta*, *Acropteryx opulenta*, *Saccopleura lycealis*, genus *Dichocrocopsis*, *Dichocrocopsis maculiferalis*, *Ischnurges bicoloralis*, genus *Hositea*, *Hositea gynaecia*, genus *Incarcha*, *Incarcha aporalis*, *Macalla pallidomedia*, *Paracraga amianta*, *Minacragides arnacis*, *Trosia nigripes*, and *Hemipecten cleptes*. All of the above insects are described from specimens captured at Hoorie, British Guiana.

RACKET FORMATION IN TAIL FEATHERS OF THE MOTMOTS

WILLIAM BEEBE

Zoologica I, No. 5, 1910, p. 141

Methods and means of denudation of the barbs of the central rectrices of the Motmots, *Momotus*, *Eumomotus sp.*, to form the characteristic racket.

NOTES ON THE ONTOGENY OF THE WHITE IBIS, GUIRA ALBA

WILLIAM BEEBE

Zoologica I, No. 12, 1914, p. 241

Breeding habits, eggs, young, food of young, development and annual changes in coloration and form of the White Ibis, *Guira alba* (Linné). With a colored plate.

SPECIALIZATION OF TAIL DOWN IN CERTAIN DUCKS

WILLIAM BEEBE and LEE S. CRANDALL

Zoologica I, 13, 1914, p. 247

Account of retention of the caudal down by attachment to the growing juvenile rectrices in *Aix sponsa* Linné, *Erismatura jamaicensis* (Gmel.), and *Merganetta columbiana* Des Murs.

NOTES ON THE BIRDS OF PARÁ, BRAZIL

WILLIAM BEEBE

Zoologica II, No. 3, 1916, p. 55

Account of a visit to Pará, Brazil, with discussion of the region, the general ecology, and of the visit of seventy-six species of birds to a single tree. Notes on some of the invertebrates of the region. Notes on the molt of some Pará birds. Annotated list of the birds observed.

FAUNA OF FOUR SQUARE FEET OF JUNGLE

WILLIAM BEEBE

Zoologica, II, No. 4, 1916, p. 107

An investigation of four square feet of debris taken from the jungle floor near Pará, Brazil, and carefully searched for minute forms of life. Accounts of the many interesting invertebrates found within the debris. Illustrations of the following new ants, *Glamyromyrmex beebei* Wheeler, and *Blepharidatta brasiliensis* Wheeler.

Also belonging to this series is the following volume, dealing with the account of a trip into the British Guiana jungle in the year 1909.

OUR SEARCH FOR A WILDERNESS

M. B. & C. W. BEEBE

8vo., 408 pages, illustrated. Henry Holt & Co., New York, 1910

Pages 111 to 398 deal entirely with British Guiana and the animal life found there.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 3

(Tropical Research Station Contribution Number 97)

A STUDY OF SOME SOCIAL BEETLES IN BRITISH GUIANA AND OF THEIR RELATIONS TO THE ANT-PLANT TACHIGALIA

By William Morton Wheeler

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

December 24, 1921

If organic evolution had stopped with insects it would still have been a succession of achievements that angels might desire to look into. The entomologist watches by the most copious fountain of wonder in the world—a well of surprises for eye and intellect.—J. ARTHUR THOMSON, "*The System of Animate Nature*," p. 545.

dealing

A STUDY OF SOME SOCIAL BEETLES IN BRITISH GUIANA AND OF THEIR RELATIONS TO THE ANT-PLANT TACHIGALIA*

By William Morton Wheeler

Introduction.

The materials for the following paper were obtained during July, August and September, 1920, while I was working with Prof. I. W. Bailey on the myrmecophytes of British Guiana. We had gone to the Tropical Laboratory of the New York Zoological Society at Kartabo for the purpose of making an intensive study of the relations of the ants to such plants as *Cecropia, Triplaris, Cordia* and *Tococa;* Prof. Bailey's investigations being primarily concerned with the anatomical peculiarities of the plants, my own with the identification and habits of their various ants. During these investigations I encountered two species of beetles of such unusual social habits that I was led to devote considerable attention to their behavior. They live in the fusiform enlargements of the petioles of a singular tree, *Tachigalia,* which is also inhabited by numerous species of ants. Both the beetles and the ants cultivate coccids in the hollow petioles, and with the beetles and coccids there are, moreover, several associated, parasitic or synœketic insects. And since there are also other insects, besides those already mentioned, associated with the plant, we may regard the latter as the focus of a very interesting and complicated biocoenose.

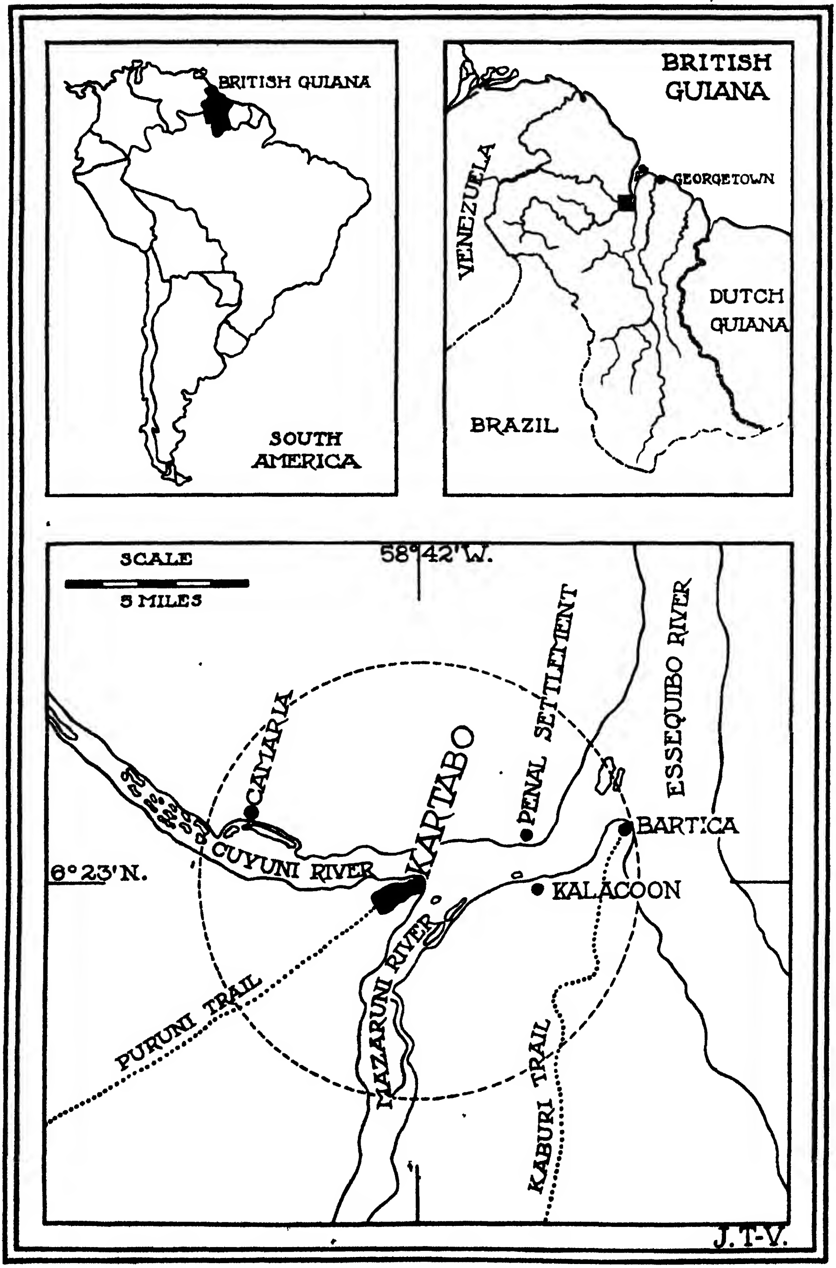
The elements of this biocoenose are so numerous and heterogeneous that I have had to appeal to several specialists for assistance in making identifications and writing descriptions. Dr. E. A. Schwarz and Mr. H. S. Barber kindly studied and described the social beetles and a little Coccinellid which feeds on their coccids. Dr. Adam Boving made a fine study of the beetle larvæ;

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University. No. 188.

Mr. Harold Morrison identified the coccids; the Hymenopterous and Dipterous parasites of the latter were studied by Prof. C. T. Brues and Dr. E. P. Felt. Dr. J. Bequaert, Prof. Herbert Osborn, Prof. J. W. Folsom and Dr. R. V. Chamberlin identified a wasp, two Membracids, a Collembolan and a Myriopod found living in *Tachigalia* petioles; and Prof. Roland Thaxter found and identified a fungus growing on the surfaces of one of the species of social beetles. I have added the reports of several of these investigators as appendices to the present paper, and wish to express my great indebtedness to all of them for their generous assistance and to Mr. Wm. Beebe for his many kindnesses to Prof. Bailey and myself while we were at Kartabo and the pains he has taken, since our return to Boston, to ascertain further facts concerning the *Tachigalia* and other myrmecophytes and to collect additional species of Formicidæ. So many of the ants inhabiting the *Tachigalia* prove to be new to science that I have had to provide a special paper for their taxonomic descriptions (Zoologica III, No. 4).

Although I have endeavored to acquire a comprehensive knowledge of the various insects associated with the *Tachigalia*, I am aware that my account must be very fragmentary. The territory covered was limited and in other parts of British Guiana the same tree undoubtedly harbors other insects. This is indicated by the few published observations on the trees of the genus *Tachigalia* and their insects in Brazil and other parts of South America. Moreover, only the leaves and petioles and their inhabitants were studied and there are probably many peculiar insects that live only in the wood and seeds or merely visit the flowers, which in some species, at least, are conspicuous and sweet-scented. The seeds were found only after they had germinated, and the trees showed no indications of flowering during our stay in British Guiana. Our inference that they might bloom during the winter months has not been confirmed, since up to the time of this writing (March, 1921), Mr. Beebe has seen no flowers on any of the trees which Prof. Bailey marked for observation. I trust, nevertheless, that my account of the *Tachigalia* biocoenose will give such a picture of the astonishing complexity and exuberance of the insect fauna of the Neotropical Region, and of the fierce competition among these organisms on the one

hand and of their intimate co-operation on the other, as to stimulate some future investigator to complete my observations. At any rate, the following pages may serve to direct the attention of our younger entomologists to one of the many wonderful, almost untouched fields for investigation in tropical America.



LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

The Tachigalia.

The Leguminous myrmecophytes of the genus *Tachigalia* comprise more than a dozen known species of trees and shrubs belonging to the forest formation (hylæa) of the Guianas and the Amazon basin. The first species, *paniculata,* was described by Aublet as long ago as 1775, and re-described by Tulasne in 1844. The former derived the generic name from the Carib "tachigali," "tachi" being the term employed by the natives of the Guianas and Brazil for the stinging ants of the genus *Pseudomyrma,* which regularly inhabit the swollen petioles of the species of *Tachigalia* and the hollow branches and trunk of the various species of *Triplaris.* Spruce (1869) was also familiar with several species of *Tachigalia* and their ant-inhabited petioles. Owing to our not finding the trees at Kartabo in bloom, Prof. Bailey and I have been unable as yet to ascertain their specific name. They closely resemble, however, at least in their younger stages, the species described by Harms (1906) as *T. formicarum* and figured by Ule (1907), who discovered it in Brazil (Plate I).

I first found the *Tachigalia* on the Puruni Trail near the Kartabo laboratory on July 22. The specimens were small and slender, from a foot and a half to six or seven feet tall, with only two or three to about a dozen leaves, and were growing in the shade. The petioles were inhabited either by beetles or by ants of the genera *Azteca* and *Pseudomyrma.* On the following day Prof. Bailey found what we at first took to be a different *Tachigalia* on the left bank of the Cuyuni River. It was a small tree, 30 to 40 feet high, with denser foliage and very different leaves. Its petioles were all inhabited by parts of a single huge colony of a yellow *Pseudomyrma.* Later, on finding more material, we became convinced that both trees were merely the juvenile and adult forms of the same plant, the former growing in the shade, the latter in the sun. Prof. Bailey found the seedlings in various stages and was able to ascertain that the seed is a peculiar

samara, not a pod as in most Leguminosæ, and that the plants grow in loose colonies, the seedlings springing up in the shade about the base of the parent tree, which rises to a height of 40 to 60 feet, with a crown of foliage at the summit of a very slender trunk.

Further search revealed the fact that the *Tachigalia* is not uncommon in many localities within a mile of the laboratory, especially along the Puruni and Cuyuni Trails. It was also found scattered through the beautiful primeval forest at Kalacoon and Baracara on the right bank of the Mazaruni and in the jungle behind the Penal Settlement on the opposite banks of the same stream. Though the tree was often found in all the localities mentioned, it is, nevertheless, rather sporadic compared with many other components of the hylæa. It may also be very local in British Guiana and the adjacent countries. This is indicated by the fact that there seemed to be no specimens of it in the herbarium of the Botanical Garden at Georgetown nor in that of the Botanical Garden at Port of Spain, Trinidad, and neither the botanists of those institutions nor the chief of the forestry department at Georgetown had ever seen the plant. Moreover, the halfbreed Indian caretaker of the Kartabo laboratory, though familiar with it and its ant-inhabitants, did not know its native name, notwithstanding his remarkably accurate memory for the aboriginal names of most other trees of the jungle. Thus we were unable to ascertain even the generic name of the *Tachigalia* till we had gone over the works on the South American flora in the library of the Arnold Arboretum.

As Prof. Bailey will publish a detailed account of the anatomical peculiarities of the tree, I may here confine myself to a brief sketch of its appearance. For the purposes of this study it will be advantageous to distinguish rather sharply between the young, shade and large, sun forms, since their insect inhabitants are, as a rule, very different. In the shade form (Plate I) the *Tachigalia* has an extremely slender, straight trunk, from about a foot to eight or twelve feet in height, with long alternate, pinnate leaves coming off of it at right angles and at such long intervals that even the smallest of the young plants

have only two or three, the largest hardly more than a dozen leaves. These are dark green, smooth and somewhat shining, a except at the base, where it forms a fusiform swelling two to four inches in length and a third to half an inch in diameter. The longer, more distal portion of the petiole bears six to eight pairs of broadly lanceolate leaflets, which are not drooping or pendant. The stipules at the base of the petiole are small and inconspicuous. The sun form (Fig. 4) is much more vigorous and has numerous branches at or near the summit of the long, slender, foot or less in length. The petiole (Fig. 5*a*) is very slender smooth, gray-barked trunk. The leaflets are pendant, more crowded, much coarser, brighter green, with more rugose surfaces and the petiole is thicker, with a large, three-cornered basal swelling more gradually continued into the leaflet-bearing portion (Fig. 5*b*). The cavity of the petiole also extends nearly throughout its length instead of being confined to the basal, swollen portion, and there are also cavities in the branches near each leaf. The stipules are large and conspicuous and palmately multifid. Forms of the plant intermediate between the shade and sun forms were rarely seen. The specific identity of the two forms was proved by finding young shoots of the typical shade form growing from the trunk of a large sun tree in an abandoned cassava patch at points where the wood had been cut back by the natives.

THE TACHIGALIA BIOCOENOSE.

The interrelationships of the various organisms constituting that portion of the *Tachigalia* biocoenose with which this paper deals, *i. e.*, the numerous insects with their parasites and satellites, that infest the young shoots and leaves, are represented in the accompanying diagram (Plate II). It will be seen that the portion of the plant which forms what may be called the center of the biocoenose is the leaf-petiole, and it is, of course, the peculiar structure of this organ that determines the specific relations of the various insects to the host-plant and is, therefore, the key to an analysis and understanding of the whole living complex. As Prof. Bailey will publish a detailed account of the

histological composition of the petiole, I here confine myself to a general description, dwelling only on the more salient features.

The petioles of the shade-plants are very long and slender and their enlargement is fusiform and restricted to the base, proximal to the leaflets. In cross-section (Pl. IV) the enlargement is nearly circular, with one surface, corresponding to the dorsal surface of the petiole, flattened. In the sun-plants the basal thickening passes gradually into the leaflet-bearing portion of the petiole and the cross-section (Pl. III, figs. 3 and 4) is distinctly triangular, one of the sides being dorsal, the two others forming together the inverted roof-shaped ventral portion, so that the petiole might be described as flattened dorsally and carinate ventrally. The dorsal surface is distinctly winged, or alate on each side. In the very young leaves the petiolar enlargement is solid, its interior being filled with juicy pith (Pl. III, fig. 3). This soon dries up, however, and is converted into a flocculent or fibrillar, cinnamon brown substance, lying loosely in a large cavity, the walls of which are lined by a thin layer of the same reddish tissue. The same kind of tissue, the cells of which are filled with a homogeneous amber-colored substance, is also continually forming in four longitudinal strands or rays in the dorsal wall of the petiole (Pl. IV, fig. 1). Later a few similar strands make their appearance also in the ventrolateral walls. Since the amber-colored substance which characterizes this tissue evidently has a high nutritive value, I shall call it the nutritive parenchyma. In a few petioles in this stage I found from four to six small Curculionid larvæ feeding on the loose material and reducing it to a red, powdery frass. Unfortunately these larvæ could not be reared, so that their specific identity is unknown. They are not, however, necessary agents in the preparation of the petioles for their future occupants.

As soon as the petiole has reached the stage just described it is evident that any small insect, sufficiently enterprisng to bore a hole in its wall, would find comfortable lodgings, which could easily be rendered even more comfortable by tossing the dried remnants of the pith out of the entrance or by compacting them in the narrow ends of the spindle-shaped cavity. And if the insect were a vegetable feeder it might find also an abundant food-supply in the remains of the pith still forming the lining

FIG 4 BRANCH OF AN ADULT (SUN) *TACHIGALIA*

The leaflets have been removed from two of the petioles

Photograph by John Tee-Van

FIG. 5. BASES OF LEAF-PETIOLE OF *TACHIGALIA* SP.

a, of young, shade tree; *b*, of large, sun tree, both nearly ½ natural size. Pieces of the older petiole and adjacent trunk have been cut out to show the cavity inhabited by *Pseudomyrma*.

of the cavity and especially in the rays of nutritive parenchyma. That the very exuberant neotropical fauna comprises a considerable number of such enterprising insects, the following observations will show.

It will conduce to clearness if we divide the insects which take possession of the petiolar enlargements into two series (Plate II). The first series comprises a small number of ants, social beetles and coccids which utilize all the advantages afforded by the petioles, *i. e.*, use them not only as dwellings for themselves and their young but also as sources of food. Among these three groups of insects the coccids occupy a peculiar and important position. They are present in considerable numbers and of all sizes in all petioles inhabited by established colonies of the beetles and ants. Specimens of the coccids from petioles of both young and adult trees were submitted to Mr. Harold Morrison, who pronounces them all, without exception, to belong to a single species of mealy-bug, *Pseudococcus bromeliæ* Bouché (Fig. 9), a well-known form which has been taken in widely scattered tropical and subtropical localities (India, Zanzibar, Brazil, Florida and even in the hot-houses of Massachusetts) and on a variety of plants (mulberry, Canna, Hibiscus, pineapple). As these insects are, of course, quite unable to make openings in the walls of the petioles, they either wander into the cavities from the surface of the plant, after the ants and beetles have entered, or they are carried in by the former insects. Once inside the petioles the coccids attach themselves to the longitudinal strips of nutritive parenchyma in the walls, insert their beaks and find an abundant supply of sap. The ants can then absorb the saccharine excrement ("honey dew") of the coccids and thus vicariously feed on the plant. The beetles, as we shall see, not only utilize this same source of liquid nutriment but also feed on the solid nutritive parenchyma of the petiolar walls.

The other series, which comprises many more forms, merely use the petioles as nesting, dwelling or hiding places. They enter petioles that have been previously occupied and abandoned, and behave in all respects like the insects which live in old oak-galls in our northern woods. They are in fact merely tenants, or inquilines, or what German zoologists call "Raumparasiten." No coccids are found in the petioles inhabited by these insects, which

may be divided into two groups, miscellaneous arthropods and ants. The former are probably very numerous but I have notes only on the following five:

1. In one abandoned petiole I found that a female katydid had enlarged the opening with her jaws, had thrust her ovipositor through it and had deposited her flattened eggs in the cavity.

2. On another occasion I found a petiole of a young plant inhabited by termites (*Nasutitermes* sp.) They had built an earthen gallery along the stem from the ground to an opening in the petiole and were living in the cavity.

3. At the Penal Settlement, near Bartica, I found in one old petiole the mature and pigmented pupa of a solitary wasp, which Dr. J. Bequaert has identified as *Podium ruficrus* Fabr. The mother wasp had stored the petiole with spiders, laid an egg on them and sealed up the entrance.

4. Another petiole, found near the laboratory, contained a small, red female centipede, identified by Dr. R. V. Chamberlin as *Otostigmus limbatus* Meinert, previously known from Brazil and Paraguay. She was coiled about her small, white, recently hatched young.

5. Some of the old and abandoned petioles on young trees were occasionally seen to be inhabited by spiders, especially by Attids.

Inasmuch as the ants comprise the more numerous and more important insects associated with the *Tachigalia* they may be considered in somewhat greater detail, and since their relations to the plant are of five different kinds (Plate II) they may be most conveniently grouped under as many captions.

1. *Defoliators.* Only one species, *Atta cephalotes* L., the common leaf-cutting ant of Central America and northern South America, was actually proved to defoliate young Tachigalias at a time when many of their petioles were not inhabited by other ants or inhabited only by recently fecundated queens of *Pseudomyrma* that had not yet produced their colonies of belligerent, stinging workers. In the jungle behind the Penal Settlement I observed a few such trees which had been either completely

defoliated or had had large semicircular pieces bitten out of their leaflets by *Atta* workers. I have no doubt that these ants would carefully refrain from thus injuring larger Tachigalias in the possession of well-developed *Pseudomyrma* colonies. In all probability the smaller leaf-cutters of the genus *Acromyrmex,* not uncommon in the same locality, may also occasionally visit and defoliate the young trees, but this was not actually observed.

2. *Attendants of Homoptera.* The terminal shoots of young plants are often infested with a small brown Membracid in all stages *(Endoastus* (?) *productus* Osborn) and peculiar flat Membracid nymphs (probably belonging to the genus *Microcentrus,* according to Osborn) the piercing mouthparts of which leave on the surfaces of the petioles permanent scars that may perhaps serve later as convenient points for the beetles and queen ants to bore into the enlargements. At least four species of ants were taken in attendance on these Membracids: *Camponotus femoratus* Fabr., *Crematogaster limata parabiotica* Forel, *Ectatomma tuberculatum* Oliv. and *Dolichoderus attelaboides* Fabr. The first two were the most frequently encountered and belong to another interesting biocoenose, that of the "ant-gardens," which I have described in a recent paper (1921), the last two were of more sporadic occurrence. A few notes on their habits are recorded in Zoologica, Vol. III, No. 4.

3. *Inquilines.* These comprise no less than sixteen different forms, representing thirteen species, belonging to the genera *Neoponera, Leptothorax, Crematogaster, Allomerus, Solenopsis, Pheidole, Camponotus* and *Brachymyrmex.* Most of them are small and all are timid and nonaggressive species which never keep coccids, and are more frequently found in other situations, especially in the dead twigs and branches of various shrubs and trees. And most or all of them merely take possession of petioles that have been previously perforated, inhabited and abandoned by other ants or by the social beetles. The inquiline ants, moreover, are confined to the young Tachigalias growing in the shade. Although the number of them I have collected is considerable and although they represent very diverse genera and even subfamilies, it is certain that further search, especially in other localities, will greatly increase the number, for the petiolar cavities of *Tachigalia* are sufficiently commodious to accomodate

at least the young colonies of nearly all of the twig-inhabiting ants of British Guiana and the list of these is a long one, comprising many small species of *Cryptocerus, Procryptocerus, Pseudomyrma, Leptothorax, Crematogaster, Azteca, Tapinoma, Myrmelachista, Camponotus,* etc.

4. *Thief-ants.* The only species belonging to this category is the tiny *Solenopsis altinodis* Forel, (Fig. 15). which is closely related to a series of "lestobiotic" *Solenopsis* species that nest in the walls of ant-or termite-nests and prey on their brood. It does not live in the *Tachigalia* petioles but enters those inhabited by the social beetles, when their entrances happen to be unguarded, and destroys their larvæ. In all probability it also attacks small, defenceless colonies of the inquiline ants and devours their brood. I infer that it nests in the ground from the fact that it often appeared suddenly in considerable numbers during the night and exterminated the colonies of the Pseudomyrmas in vigorous *Tachigalia* and *Triplaris* branches that had been left on a table in the yard of the laboratory. I have also seen it wandering about on the laboratory tables indoors, over the foliage of the undergrowth in the dark jungle or feeding on the pulp of injured fruits of the water cocoa (*Pachira aquatica* Aubl.) growing along the river banks.

5. *Obligatory Ants.* I would thus designate the ants that are definitively attached to the *Tachigalia* as their host-tree. There are only four species: *Pseudomyrma damnosa* sp. nov., (Fig. 13), *Ps. maligna* sp. nov. (Fig. 14), with its two varieties, *cholerica* and *crucians, Azteca foveiceps* sp. nov. (Fig. 16), and *A. traili* Emery. The last is doubtfully included for reasons to be given below. The recently fertilized queens of these ants perforate and enter the petioles of young Tachigalias growing in the shade, close the openings behind them with particles gnawed from the walls and eventually produce their broods in the cavities. Occasionally queens of the two species of *Pseudomyrma* or of these and *A. foveiceps* may be found, each in a petiole of the same plant and even of one with only a few leaves. That the founding of the colonies may be frought with many dangers is shown by the fact that dead queens are often found shut up in the petioles precisely as in the case of the *Azteca* queens in the internodes of young Cecropias. Some of the unfortunate in-

sects undoubtedly succumb to hunger or the attacks of fungi, but in many cases they seem to be killed by alien ants or by the beetles boring into the same petioles. If the queens survive, however, and produce their broods of workers, the latter open from the inside the entrances made by the queens and eventually take possession of the whole plant. Since all the petioles of larger trees are invariably inhabited by a single flourishing colony of a single species or variety, we must suppose that the offspring of different queens on opening their respective petioles either fight for the possession of the plant or, if they belong to the same species or variety, unite to form a single polycladic colony. The fact that the petioles of large trees contain several deälated fertile females of *Ps. damnosa* or *maligna* would seem to indicate that the eventual climax colony, as it may be called, is established by alliance of several broods rather than by the survival of the offspring of a single queen. Furthermore, the climax colony seems to be far too populous to represent the offspring of a single mother.

No sooner are the petioles opened by the young broods of workers than the coccids enter or are carried in by the ants and attach themselves to the areas of nutritive parenchyma which furnish optimum conditions for feeding and growth. Here they can multiply and be cared for by the ants which undoubtedly find in them a most welcome source of food. As the tree grows and puts forth new leaves, each young petiole as soon as it has reached the proper size is perforated by a detachment of ants and coccids. The later leaves, as I have stated, have cavities extending nearly the entire length of the petioles and adjacent to their insertions there are also cavities in the branches, which are likewise entered and occupied by the insects. The largest leaves have petioles with such broad cavities at their bases that the ants find it necessary to make chambers in them by building carton partitions. The materials for the carton are gnawed from the walls. *Azteca foveiceps* builds a much more elaborate system of partitions than the Pseudomyrmas. This is not surprising, because the Aztecas are nearly all wonderful experts in carton construction.

When the climax stage of the *Tachigalia* biocoenose has been reached, it has been reduced to only three organisms, the plant,

the coccids and *Azteca foveiceps* or more frequently one of the two species of *Pseudomyrma* or one of the varieties of *Ps. maligna.* Merely rapping on the tree then reveals the situation, for the angry workers rush out of the petioles, cover the leaflets, trunk and branches and can be readily identified by their size and color, *Ps. damnosa* being yellow, *A. foveiceps* and *Ps. maligna* var. *crucians* black; *maligna* s. str. and its var. *cholerica* both black with yellow markings, but differing in size. Of *A. traili* only a single very young colony was seen, and this was inhabiting a petiole of a small *Tachigalia.* There were coccids in the cavity of the petiole, however, and both for this reason and because the ant is known to be associated with other myrmecophytes, I have included it among the obligates in the diagram. It is, in fact, conceivable that in some localities in British Guiana *traili* may be the dominant species and replace *foveiceps* in the climax stage of the biocoenose.

I have noticed unmistakable indications of two other insects on young Tachigalias, both attacking the foliage. One was a caterpillar of some kind, which had gnawed the leaflets of a few plants and had disappeared, so that I was unable to secure a specimen for identification. The other was an Itonidid gall which occurred in great numbers on a single plant on both the upper and lower surfaces of the leaflets. This gall was 2-4 mm. long, erect and cylindrical, with a conical tip, and somewhat resembled the galls produced by *Cecidomyia caryæcola* Osten Sacken on the leaves of our northern hickories. The smaller galls were undeveloped and contained no larvæ but each of the larger ones had a round hole at the tip and contained in the base of its tubular cavity a cylindrical cocoon enclosing the pupa of a small parasitic Hymenopteron, evidently a Eulophid. Some of the specimens were fully pigmented and nearly ready to hatch, others had been killed by an *Entomophthora*-like fungus. Probably the mother of the parasite had made the round hole in the tip of the gall in order to enter and oviposit on its maker.

It will thus be seen that the *Tachigalia* biocoenose comprises at least 51 different organisms, the host plant and 50 organisms associated primarily with its leaves and terminal shoots or secondarily with the organisms thus associated.

THE SOCIAL BEETLES.

A. COCCIDOTROPHUS SOCIALIS SCHWARZ AND BARBER.

After a careful taxonomic study of the beetles which I found in the *Tachigalia* petioles, Messrs. Schwarz and Barber conclude that they belong not only to perfectly distinct species but to different genera of the family Silvanidæ. While still at Kartabo I convinced myself of their specific difference, but unfortunately not till it was too late to make a detailed study of the differences in their behavior. While the species described in Zoologica III, No. 5 as *Coccidotrophus socialis* was so abundant that I obtained nearly four hundred of its colonies, *Eunausibius wheeleri* was so scarce that I encountered it in less than a dozen petioles. For some time I took it to be merely a depauperate variety or aberration of the *Coccidotrophus* and therefore gave it little attention. Finally, when I had come to appreciate its distinct specific status, my stay at the laboratory was drawing to a close and I could secure only a few of its colonies. My account, therefore, relates almost entirely to *Coccidotrophus* and my notes on *Eunausibius* yield only a few rather summary remarks which may be most conveniently relegated to a brief separate caption (p. 88).

The *Coccidotrophus* (Plate III, fig. 2; Plate VI, figs. 1-5) was taken only near Kartabo and only in the petioles of young Tachigalias growing in the shade along the Puruni, Hacka and Cuyuni trails, within a mile of the Tropical Laboratory. Although the tree was not uncommon in the jungle behind H. M. Penal Settlement and along the trails in the primeval forest near Kalacoon and Baracara, I found no traces of the beetle in these localities. It would seem, therefore, to be rather local. Its body is flattened-cylindrical, long, slender and parallel-sided, with short, stout legs, the femora, especially the fore pair, being conspicuously thickened. It varies in size from 3.5 to 4.5 mm. and when fully mature is deep castaneous brown to almost black, with more reddish appendages. Specimens recently emerged from the pupa, however, are pale reddish testaceous, with more yellowish elytra. The surface of the body is shining and glabrous, the head and thorax punctate, the elytra punctate-striate. The head bears a singular and significant resemblance to that of certain small ants of the genus *Cryptocerus*. The antennæ are short,

compactly jointed and distinctly clubbed at the tip. The female is, perhaps, somewhat smaller than the male, but I have been unable to detect any other external differences between the sexes, and Schwarz and Barber in their more careful study of the structural peculiarities of the species, have been no more successful. For further details the reader is referred to their taxonomic description in Zoologica III, No. 6.

The eggs (Fig. 11) are pure white, regularly elliptical, 0.55 long and 0.25 mm. broad, with rather thick, leathery, smooth and shining chorion. The larva is described and figured in great detail in Dr. Boving's article (Zoologica III, No. 7, Plates VII and VIII). In life it is whitish and beautifully translucent so that the straight alimentary tract and its contents can be distinctly seen, but as maturity approaches the body becomes more opaque and milk-white, owing to a considerable increase in the fat-body. The pupa is even more opaque, but just before eclosion becomes yellowish or testaceous, with pigmented eyes. Both beetle and larva are very active and alert, the latter at all times, the former when hungry or disturbed. At other times the beetle is rather sluggish or quiescent, but shows no tendency to "feign death" when handled. Though its wings are well-developed (Plate VI, fig. 5) I have never seen it attempt to fly. The pupa (Plate IX, figs. 19-21) is also very active when stimulated, wriggling its abdomen from side to side, but is unable to move about.

The beetles enter petioles which have either not been previously perforated by other insects or those which have been occupied for some time and have then been abandoned by ants or other beetles or have been occupied by queens of *Pseudomyrma* or *Azteca* that have died before they could produce their broods of workers. The beetles either enter as a single pair or one beetle enters and is very soon joined by an individual of the opposite sex. I have been unable to decide which of these methods is followed or whether the opening in the petiole is made by the male or the female or by either indifferently. Certainly the great majority of colonies in their first, or incipient stage consist only of a male and a female beetle. On the rare occasions when only a single beetle was found in a petiole, the other may have escaped or eluded my attention while I was cutting into the cavity. Twice I have actually seen both beetles

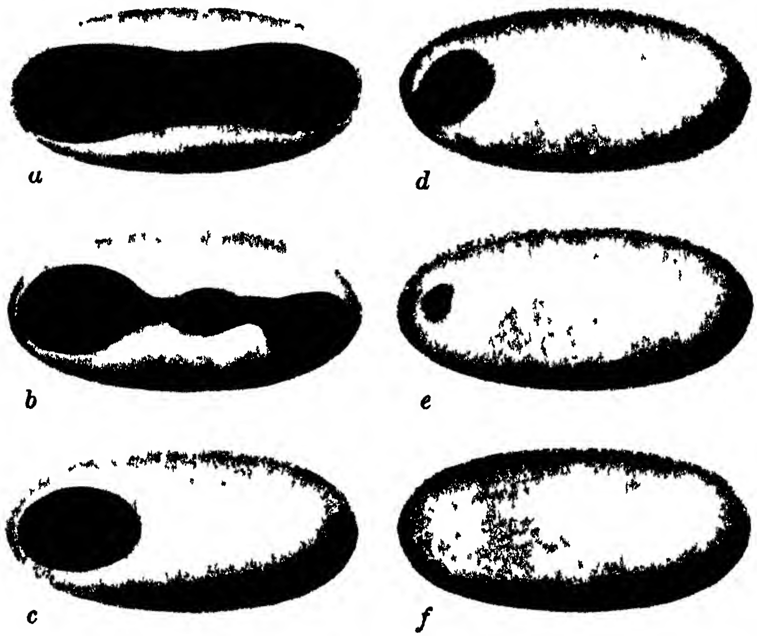


FIG 6 SIX SUCCESSIVE STAGES IN THE CONSTRUCTION OF THE COCOON BY THE FULL-GROWN LARVA OF *COCCIDOTROPHUS SOCIALIS*

See text for explanation

in a cavity diligently cleaning it up for occupancy. Such house-cleaning is necessary both in previously unoccupied and in previously occupied petioles since in the former the particles of fibrillar or powdery pith, which partially fill the cavity, and in the latter the dead bodies of ants, beetles, etc. must be removed. The entrance opening gnawed in the wall is transversely elliptical and just large enough to admit the slender bodies of the beetles. It is most frequently made in the lateral wall some distance from the narrow ends of the petiolar swelling. The petiole occasionally has several openings, sometimes as many as five to seven. I believe that each of these must be the work of the founders of one of the colonies which have successively occupied the same cavity. In other words, the pair of beetles seems not to utilize the openings of previous occupants for the purpose of entering the petiole but insists on making an opening of its own, so that the considerable number of orifices occasionally noticed in an old petiole represent the number of colonies of beetles or potential colonies of ants that have from time to time taken up their abode in its cavity.

The beetles accomplish the removal of the loose pith or the remains of previous tenants by pushing this refuse into the pointed ends of the cavity with their flattened heads, much as a slovenly servant might tidy a room by sweeping things under the furniture or into closets. Smaller particles of pith are sometimes thrown out of the entrance but the decomposed and more or less disarticulated bodies of queen ants and beetles are too voluminous to be disposed of in this manner so that they can only be packed away compactly into the ends of the cavity. This behavior brings the insects into contact with the outermost layer of pith still adhering to the ligneous walls of the cavity and the strips of nutritive parenchyma laden with amber-colored substance. (Plate IV, fig. 1, Plate III, fig. 5). That this tissue actually constitutes the food of the beetles is proved not only by finding it in their intestines but also by actually observing their feeding activities. Very soon, however, young coccids begin to enter the petiole through the opening made by the beetles and take up their positions on the walls of the cavity and preferably along these very strips of nutritive tissue which, as the beetles feed, become gradually deepened into grooves. The

coccids station themselves in a row in each groove, with the long axes of their bodies parallel with the long axis of the petiole. Since both beetles and coccids center their feeding activities on the tissue forming the floor of these grooves it is important that they shall be kept clean so that the parenchyma, which is continually proliferating, can be easily reached by both species of insects. (Plate III, fig. 5). Hence the beetles carefully deposit their feces, or frass, which has a chocolate brown color, on the areas between the grooves. As time goes on the accumulations of frass acquire the form of more or less longitudinal ridges projecting into the petiolar cavity (Plate IV, figs. 2-3 and Plate V). In many petioles these ridges are strikingly regular, in others more vermiculate, interrupted or anastomosing. In old petioles inhabited by old colonies of *Coccidotrophus* the interior of the petiolar cavity presents the appearance of the figures on Plate V. In addition to these frass ridges the beetles also build a more or less circular wall of the same substance around the entrance, so that the latter is converted into a short tube, in which one of the beetles often stations itself on guard for hours at a time, with the long axis of its body at right angles to the long axis of the petiole and its flattened head exactly filling the elliptical orifice. (Fig. 11). From time to time the beetle may project its antennæ out into the air and wave them about, so that the petiole from the outside suggests the nest of one of the smaller species of *Cryptocerus*, with a soldier or worker ant on guard at the orifice.

The female beetle begins to lay her eggs either before or after the entrance of the coccids. They are deposited singly along the edges of the frass ridges and evidently at intervals of several hours or even days, for dissection of the beetles shows that only a few eggs mature at a time in the ovaries. They are glued to the wall of the petiole rather firmly and always with their long axis parallel with its long axis and that of the food-grooves and frass ridges (Fig. 11). As I have not witnessed oviposition I have been unable to determine the length of the embryonic period. The eggs hatch, of course, at intervals, so that the larvæ vary greatly in size, some being very small and evidently just hatched, others a third or half-grown or actually full-grown and ready to pupate. Like the beetles, the

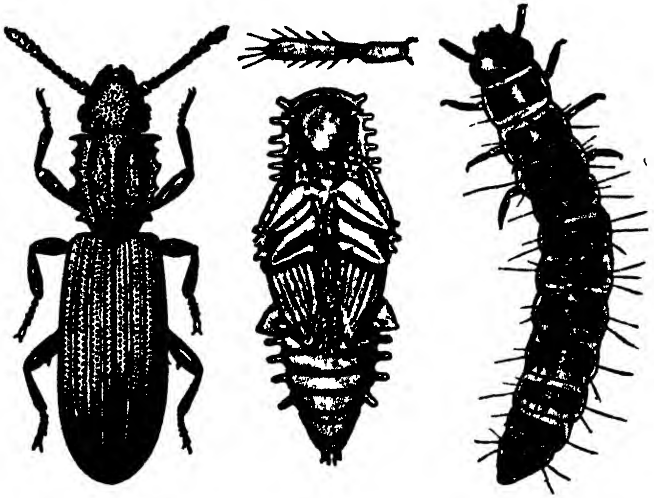


FIG 7. *ORYZAEPHILUS SURINAMENSIS* L

Beetle, pupa and larva, showing the teeth on the sides of the pronotum of the beetle and tubercles of the pupa in which they are formed Courtesy of the Federal Bureau of Entomology.

larvæ feed on the nutritive parenchyma. Its amber colored cells in the intestines may be distinctly seen through the clear integument and body cavity of the larvæ. The colony, which is now in its second stage consists of the pair of parent beetles, about one or two dozen larvæ, mostly immature and in most cases of about the same number of young or half-grown coccids.

When mature the larvæ make brown cocoons and pupate in them, as will be described in detail below. These are formed singly and the beetles emerging from them remain in the petiole with their parents and larval brothers and sisters, mate and produce eggs and larvæ in turn, thus leading to the third or climax stage of the colony, which may eventually consist of several dozen beetles of both sexes and numerous larvæ and pupæ in all stages of development. The coccids also increase in number, so that the cavity of the petiole sometimes becomes so crowded that its inmates must find their movements greatly impeded. In the meantime the old and exhausted beetles gradually die off and their bodies are consigned to the refuse accumu-

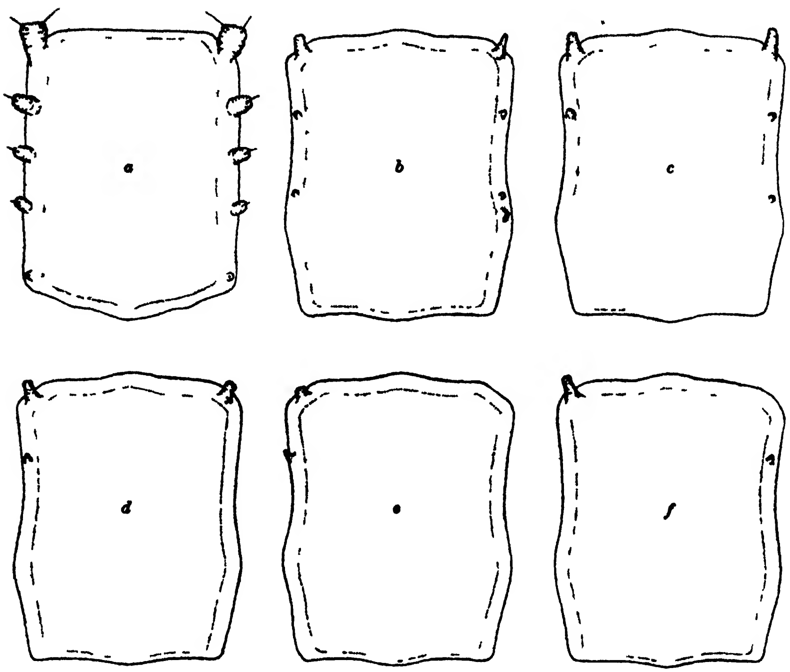


FIG. 8
a, pronotum of pupa of *Eunausibius wheeleri* showing lateral tubercles; *b*, to *f*, pronota of five pupæ of *Coccidotrophus socialis*, showing vestigial lateral tubercles and their variation.

lations, or kitchen-middens in the pointed ends of the cavity. When this crowded condition is reached, beetles begin to leave the colony either singly or in pairs, seek and enter other petioles of the same or other Tachigalias and thus establish new colonies.

In order to study the stages of colony development just described as well as those that supervene, I found it necessary to split each petiole longitudinally and to place its two halves, with their cavities turned outward in a slender vial or test-tube plugged with cotton. The cotton could be pushed in till it held the two halves firmly against the inner surface of the glass. Through the latter the behavior of the beetles could then be studied with the pocket-lens (magnifying 10-20 diameters) or the binocular dissecting microscope. Splitting the petiole, of course, so greatly disturbs the insects that many of them at once escape into the tube. Moreover, a certain number are killed or injured by the

knife-blade. But all the uninjured soon return to the two half-cavities and remain in them. At first I carefully kept the tubes in the dark, but I soon found that they could be left in the diffuse day-light on my table without disturbing the activities of the insects. It was necessary, however, to keep them in a horizontal position, like that of the petiole on the living plant, for when they were placed upright, gravity seriously interfered with the activities of the beetles and especially of the larvæ, causing them to drop and accumulate at the lower ends of the cavities or of the tubes. Of course, this position did not interfere with the coccids which remained attached by their sucking mouthparts to the nutritive parenchyma. Colonies of *Coccidotrophus* can be kept in tubes and under close observation for a week to ten days but by the fifth or sixth day the petioles are apt to become so dry even during the rainy season that the beetles, larvæ and coccids become demoralized. The modifications of behavior thus induced will be considered in the sequel.

There is, perhaps, nothing very remarkable in the fact that both the beetles and their larvæ feed on the nutritive parenchyma of the *Tachigalia*, since other Silvanidæ, e.g., certain species of *Oryzæphilus, Silvanus, Cathartus* and *Nausibius* are known to be vegetarian, but the fact that both the imaginal and larval *Coccidotrophus* actually solicit and imbibe the saccharine excrement ("honey dew") of the coccids, is so unusual and startling that it will be advisable to give a more detailed account of these insects and of their treatment by the beetles.

The adult female *Pseudococcus bromeliæ* (Fig. 9) measures nearly 3 mm. in length and is broadly and regularly elliptical, evenly convex dorsally, flattened ventrally and of a pinkish flesh-color or pale dull red, but the body is so completely covered with snow-white wax as to be scarcely visible in healthy specimens. The wax is secreted in a thin, even, mealy layer over the dorsal surface but around the periphery of the body as a regular fringe of stiff, blunt pencils which are longest on the posterior segments, somewhat shorter on the anterior border of the head and still shorter along the sides. Large specimens of the insect are less numerous in the petioles than the smaller or recently hatched individuals, many of which scarcely exceed .5 mm. in length. These are reddish because they have not yet

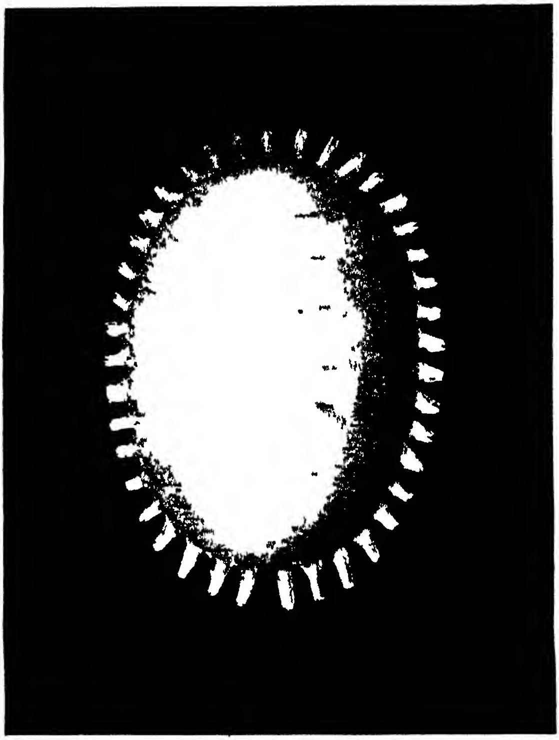


FIG 9 *PSEUDOCOCCUS BROMELIAE* BOUCHE
Sketch of an adult living female with intact covering and peripheral pencils of wax.

secreted an appreciable quantity of wax from their dorsal integument, and lack the peripheral fringe of snow-white pencils. I have not seen the males. Young individuals are rather active, not infrequently moving about in the petiole, but the older ones remain stationary in the food grooves till the petiole begins to dry up, when they take to wandering about aimlessly in search of more succulent pastures.

In specimens of the *Pseudococcus* treated with caustic potash and stained according to the method recommended by MacGillivray (1921, Chapter II), the details of the integument are clearly visible (Fig. 10). Only a few of the structures are of interest in connection with the following behavioristic account, such as the anus, which is on the ventral surface of the flat-

tened posterior border of the body, and, on the dorsal surface, two pairs of peculiar organs which have the form of transverse, mouth-like slits with thick lips. One pair of these organs is situated near the posterior corners of the head, the other between the sixth and seventh abdominal segments. Coccidologists have long been familiar with these organs in certain genera of mealy-bugs of the subfamily Eriococcinæ, and have called them "eye-like glands" "cicatrices," "osteoliform or labiate foveæ," or "dorsal ostioles." Šulc called them "adipopugnatorische Organe" and MacGillivray has recently dubbed the two pairs "cephalabiæ" and "caudalabiæ" respectively, terms so barbarous that they make one's flesh creep. I shall call them anterior and posterior ostioles. Berlese regarded them as apodemes, or invaginations of the integument for the insertion of muscles. Comstock, Newstead, Šulc and MacGillivray regard them as glands. In 1882 Comstock stated that he had "observed in *Dactylopius* a pair of openings on the dorsal side of the sixth abdominal segment, which are evidently homologous with the honey tubes of Aphididæ. A female mealy-bug was gently rubbed near the caudal end of the body, when suddenly there appeared two drops of a clear fluid, resembling in appearance the honey-dew of plant-lice. This experiment was repeated many times and with many specimens. Mr. Pergande assures me that he has observed a similar excretion from a pair of openings on the cephalic margin of the first thoracic segment." Comstock was, of course, under the erroneous impression that the honey-dew of aphids is a secretion of the cornicles instead of being the excrement of the insects and therefore extruded from the anus. According to MacGillivray: "There can frequently be observed on living specimens a small globule of a clear fluid over the mouth of each labia, more frequently the caudalabiæ than the cephalabiæ, so that they are probably also glandular in structure as suggested by Comstock. For, as he suggested, when the specimens are stroked with a pencil or dissecting needle, the insect will hump up its back and extrude a globule of liquid. The insect is unable to repeat this operation until the pocket is again filled with the clear fluid. Specimens have been observed to extrude globules from all four labiæ at the same time. The labiæ undoubtedly have a glandular function which is probably of later origin than their earlier function, a parademe for the attachment of muscles."

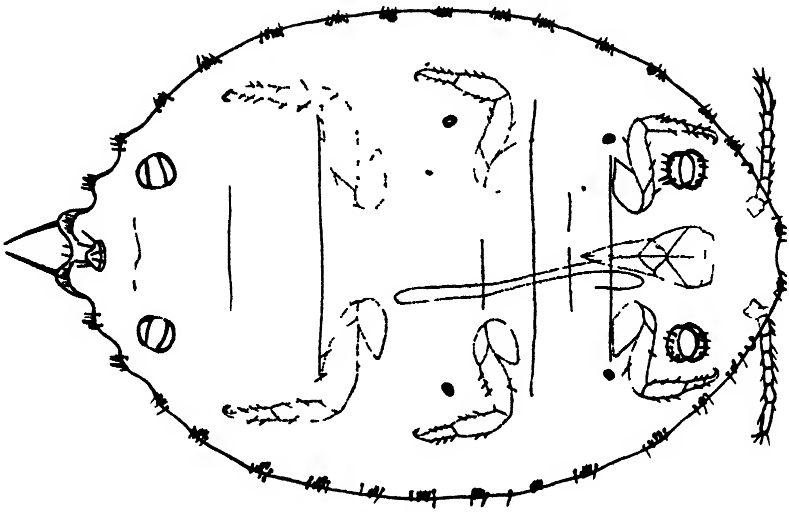


FIG. 10. *PSEUDOCOCCUS BROMELIAE* BOUCHE

Adult female treated with caustic potash to show the openings of the anterior and posterior ostioles, anal orifice, etc. The specimen is mounted dorsal surface uppermost.

Šulc (1909) made a histological and physiological study of the anterior and posterior ostioles in *Pseudococcus farinosus* De Geer. When the female of this insect was stroked with a brush, each of the ostioles suddenly emitted a droplet of orange-yellow liquid, which partly adhered to the brush and partly rolled off from the wax-powdered dorsal surface. The liquid was found to consist of cells and a few blood-corpuscles. Šulc concludes that the organs are repugnatorial, and that their secretion is employed like that of the cornicles of aphids for gluing up the appendages of insect enemies. His account of the function of the secretion is by no means convincing, since it might also be regarded as an exudate, derived directly from the fat-body, like the exudates produced by various termitophiles and myrmecophiles (*Cf.* Wheeler 1918), and hence employed for allurement instead of repulsion.

Returning to a consideration of the *Coccidotrophus* in the *Tachigalia* petioles, we find that the beetle often remains motionless for hours at a time, in a food-groove, which just fits its long slender body. If at other times, when it is moving about, it

chances upon a coccid, it stops suddenly and seems at once to become more alert or excited, for as soon as its clubbed antennæ touch the dorsal surface of the insect, their beat, hitherto leisurely and exploratory, becomes greatly accelerated. With each beat, each antenna rapidly describes a minute transverse ellipse on the surface of the coccid, and the beats of the two appendages seem not to be quite synchronous. At the same time the beetle, with a much slower rhythm, rocks its body forward and backward by bending its legs, while the mobile articulations between the head and prothorax and between the prothorax and mesothorax enable it to cover more of the coccid's dorsum and to keep the antennal clubs in contact with its rounded surface. While engaged in this perfomance the beetle resembles an expert pianist moving his hands from side to side over the key-board, or a masseur with his hands in soft gloves, massaging a patient. The beetle undoubtedly distinguishes a large coccid's posterior from its anterior end, since it lavishes most attention on the former. It seems, however, to be quite as interested in the medium-sized or smallest coccids and will spend just as much time in stroking them. The time devoted to the performance in any particular case seems to vary directly with the beetle's appetite or thirst. A beetle may thus spend ten, twenty or even forty or more minutes massaging a single coccid, with occasional short pauses. After a coccid in the proper condition has been stroked in this manner for a few moments it may slowly turn up its wax-penciled posterior segments and discharge from the anal orifice a perfectly limpid droplet of sweet excrement, which the beetle at once greedily swallows. The coccid then flattens down its posterior segments and the beetle resumes its massage. The coccid may thus contribute a droplet every few minutes or it may remain inert and unresponsive. An ant confronted with such a situation would take the hint and at once look up another coccid, but the beetle stubbornly keeps on and may work for an hour or more without receiving another drink. Usually, however, some of the larvæ or one of the other beetles of the colony intervene and the scene may change, as described in a later paragraph.

That the antennæ of the beetle are beautifully adapted for stroking the coccids is apparent at a glance (Plate III, fig. 2,

Plate VI, fig. 1). Their compact structure and clubbed extremities recall the antennæ of many myrmecophilous beetles or of certain ants, for many of these insects, of course, use their antennæ in soliciting liquid food from one another. The basal joint of the *Coccidotrophus* antenna is even elongated to form a crude scape, although the remaining joints do not form an angle with it as in ants. The relations of the beetle to the coccids, moreover, are physiologically similar to those of symphilic beetles to the host ants that feed them with regurgitated liquids, and the *Coccidotrophus* like the symphiles has a short, broad tongue and short labial palpi. Wasmann (1896) and Escherich (1902) have dealt with these antennal and labial adaptations in detail, pointing out that the tongue in symphilic beetles becomes short, broad and spoon-like and that the palpi, especially those of the labium, become shorter and have a reduced number of joints. Precisely this condition is seen in the labium of *Coccidotrophus* as shown in the figure of Schwarz and Barber (Pl. VI, fig. 1). The greater development of the maxillary palpi indicates that they may occasionally function like the antennæ in soliciting honey-dew.

Coccidotrophus larvæ of all stages, from those just hatched and less than a millimeter in length, to those almost four millimeters long and nearly ready to pupate, likewise solicit and obtain food from the coccids by stroking them with the antennæ. The small beetle larvæ show no preference for small coccids since just hatched larvæ are often seen on the backs of adult female coccids, feverishly stroking their waxen surfaces and full grown larvæ may often devote themselves to coccids smaller than their heads. The movements of the larva's antennæ, though similar to the antennal strokes of the beetles, cover a smaller portion of the coccid but the larvæ reinforce the titillation by a simultaneous use of the maxillæ and maxillary palpi. The larva is almost or quite as persistent as the beetle and drinks up the periodic globules of honey-dew with quite as much gusto. Both beetles and larvæ, however, stroke the dorsal surfaces of the coccids so gently that their waxen bloom is neither removed nor diminished even after the most prolonged solicitations.

In connection with the behavior of the larva, Dr. Böving's figures of its mouthparts and antennæ are very interesting and

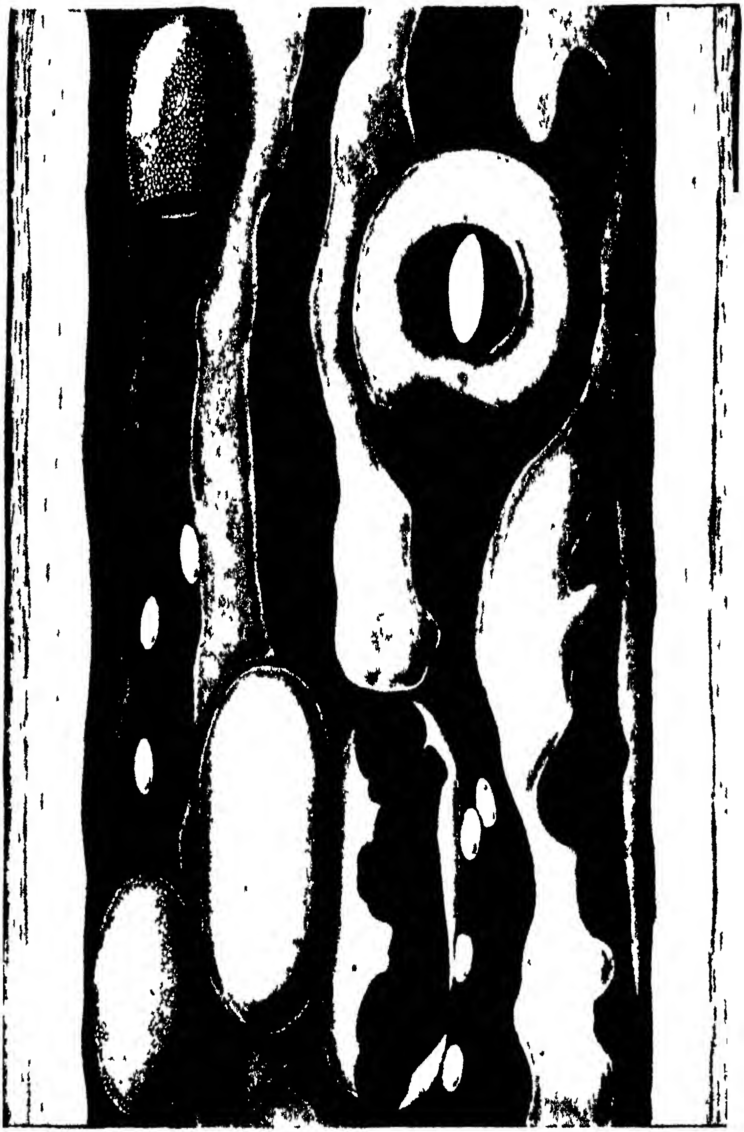


FIG. 11. ENLARGED DRAWING OF A PART OF THE WALL OF A *TACHIGALIA* PETIOLE INHABITED BY *COCCIDOTROPHUS SOCIALIS*.

Showing the food grooves and frass ridges, the entrance with its wall, the eggs, an intact and broken cocoon of the *Coccidotrophus* and two cocoons of *Blepyrus tachigaliae*, one of them after the eclosion of the parasite.

suggestive. It will be noticed that his Figs. 1, 2, 5, 8, 16, Plates VII and VIII etc. show that the tongue is large and flat like a spatula or ladle and well-adapted for receiving the globules of coccid excrement. The labial palpi are very small and 2-jointed, but the maxilla is large, with extensive stipital articulation and a large lacinia tipped with a claw-like tooth and fringed with stiff hairs along the medial border. The maxillary palpi are long and 3-jointed and the large articular membranes of the separate joints suggest great mobility. The antennæ are unusually interesting (Plate VII, figs. 1, 2, 5, 7). Though they consist of only three joints, the second is greatly elongated and distinctly drum-stick-shaped, the apical joint being much reduced to form merely a sensory cap for the second joint. Now this drum-stick-type of antenna is precisely the one found in a long series of symphilic ant-guests of the Coleopterous family Clavigeridæ *(Fustiger, Rhynchoclaviger, Adranes,* etc.), which use their antennæ for soliciting liquid food from their hosts. Dr. Boving's figures of other larval Silvanids and of genera belonging to closely allied genera of the Cucujid complex, namely *Cathartus* (Plate VIII, fig. 12), *Nausibius* (Plate VIII, fig. 18), *Dryocera* (Plate IX, fig. 33), *Telephanus* (Plate X, figs. 34, 37) and *Scalidia* (Plate X, fig. 39), show very different conditions. Thus we may say that the antennæ and maxillæ of the *Coccidotrophus* larva are specially adapted to their active rôle of soliciting and the labium to its passive, spoon-like rôle of receiving the liquid excreta of the *Pseudococcus.*

The question naturally arises as to the function of the anterior and posterior ostioles, which, as I have shown, are highly developed in *Ps. bromeliæ,* and the probability of their secreting substances that may be ingested by the beetles. Unfortunately I did not know of the existence of the ostioles while I was at Kartabo. My attention was called to them by Prof. Mac Gillivray several months after my return. I feel very confident, nevertheless, that these organs in *Ps. bromeliæ* cannot have the function ascribed to them by Šulc in *Ps. farinosus.* I have so carefully watched the coccids of all ages that I could not have overlooked the emission of orange-yellow droplets from the ostioles or of any sticky liquid that would glue up the appendages of small insects. The smallest beetle larvæ are so delicate that

they are at once immobilized or impeded in their movements when they happen to run or fall into a minute drop of water, and if the *Ps. bromeliæ* were at all hostile to the beetles or their larvæ in the manner described by Šulc, their presence would not only be a nuisance but a serious menace to the colonies. The further fact that the coccids in a petiole are frequently decimated or even exterminated by several small predatory insects (*vide infra* p. 78) is also unfavorable to Šulc's contention.

I am, of course, willing to admit that the ostioles may be glands or exudate organs which secrete substances that may be ingested by the beetles and their larvæ, but the closest observation of which I was capable showed that the only liquid visibly imbibed by the *Coccidotrophus* was the saccharine excrement, or honey-dew. If the secretion of the ostioles is a liquid, it must be emitted in droplets too minute to be visible under a Zeiss lens magnifying 20 diameters, or it must be a volatile substance like that secreted by the peculiar tubular organs which occur on the eighth abdominal segment of many ant-attended Lycaenid caterpillars and have been described by de Niceville (1890), Thomann (1901) and others.[1] That the ostioles of *Ps. bromeliæ* may actually emit some substance attractive to the beetles and their larvæ is indicated by their often very prolonged stroking of the dorsal, lateral or anterior portion of a coccid. That they prefer to stroke its terminal abdominal segments may be due to the fact that that region bears both the anus and the posterior pair of ostioles.

The attraction of the mealy-bugs, whether due solely to their ability to excrete honey-dew or because they can also secrete some delicious exudate or fascinating aroma, is so great, that in populous colonies a single coccid may often become the center of a circle of actively competing beetles and larvæ of various sizes. This is not so apparent in colonies that have just been collected and placed in glass tubes, because the petiole still contains a certain amount of sap and the coccids are able to excrete normally, but after the colonies have been kept for several days or a

[1] Conf. also the paper of Newcomer (1912), who figures a section of one of these organs in *Lycaena piasus* (Pl. 2, Fig. 3). Although he believes that the tubular organs are not glandular, the structural details certainly seem to support Thomann's contention.

week and the supply of water in the plant tissues has considerably diminished, the excretions of the coccids are less frequent and copious, so that the beetles and larvæ become more and more thirsty and therefore more desperate and exacting. Thus by the very simple device of keeping the colonies for some time in tubes, it is possible greatly to exaggerate the attentions of the beetles and their larvæ to the coccids and to witness certain peculiarities of behavior which are less obvious in recently collected colonies.

When a number of thirsty beetles and larvæ surround a large coccid, all stroking different parts of its dorsal surface and periphery, only the individual that happens to be stationed at its posterior end is able to secure any honey-dew. The beetles and larvæ all keep at work, however, till the antennæ of two of them happen to meet. Then the larger individual stops stroking for a moment and butts its competitor with the side of its head. If the group is formed by a single beetle and several larvæ, the beetle being the stronger, soon pushes any larva with which it may come in contact away, but the latter usually at once returns and resumes its stroking till contact with the beetle again occurs and the butting is repeated. When several larvæ of different sizes have preempted a coccid, the largest treats the others in the same manner. This behavior is so suggestive of that of a number of pigs eating out of the same trough that one can hardly doubt that something more than a mere reflex is involved in the butting. The larger beetle's or larva's indefatigable perseverance in butting is only equalled by the pertinacity with which the butted individual keeps returning and resuming its stroking movements. I can illustrate this best by transcribing a few observations from my note-book.

August 10, a beetle was seen standing over the posterior end of a large coccid and stroking it busily. At short intervals the coccid raised its anal segments and discharged a minute limpid globule of honey-dew, which was at once avidly seized and swallowed by the beetle. During 11 minutes the coccid raised its tail 25 times and the globule could be distinctly seen on most occasions, as the beetle paused suddenly in its manipulations and moved its labium and palpi each time a globule was imbibed. Sometimes the beetle would pause for a moment,

before proceeding with its titillation and remain with its head flattened down, even when the coccid failed to move its anal segments. Once a large larva came up and endeavored to get some of the excretion but was promptly butted away, and once another beetle was treated in the same manner. After the 25 feedings the beetle moved away and another beetle came up and received from the same coccid four globules in less than two minutes.

August 12, I observed a beetle (No. 1), which was red and therefore immature, soliciting from a nearly full-grown coccid in a petiole collected a few days previously and already beginning to become dry. The beetle stroked the coccid for 15 minutes, during which time the latter produced only five droplets of honey-dew at intervals of two to five minutes. Then a mature, dark colored beetle (No. 2) came up and began to stroke the anterior end of the coccid, gradually moving back over it. Whenever the beetles met they butted each other with their heads or even locked mandibles for an instant and then returned to their former position and occupation. Beetle No. 1 worked for another 15 minutes without a reward. The coccid then rotated 180 deg. on its dorsoventral axis so that its anal end was now presented to beetle No. 2, and inserted its beak into another part of the nutritive parenchyma. The beetle at once became more alert and accelerated the beat of its antennæ. During the succeeding eight minutes it received seven globules of honey-dew in quick succession, probably as a result of the coccid's change of pasture. Throughout this period beetle No. 1 kept titillating the coccid's side, pausing now and then for a few seconds, and after 40 minutes from the time I began the observation, moved away. Beetle No. 2 continued to stroke the coccid for some time, but I did not follow its behavior further.

In another colony at 8 P. M. on the same day I noticed a nearly mature beetle (No 3) vigorously stroking the hind end of a small coccid, while its sides were being stroked simultaneously by two just-hatched larvæ (A and B). From time to time other beetles and older larvæ came up and joined the party. Beetle No. 3 continually butted the newcomers away and they at last rather reluctantly departed, leaving the original trio in possession of the coccid. Every few seconds the beetle gave

one of the larvæ a shove with its head, but the tiny creature instantly returned and went on with its stroking. At 8.14 the beetle gave A such a vigorous knock that it stayed away from the coccid for some time. B, however, kept returning so pertinaceously that the beetle twice seized it in its mandibles for an instant and then dropped it. The larva was uninjured, however, and at once returned and went to work. Then the periodic butting continued till 8.35 when larva A returned and went to work with B on the side of the coccid. One or the other was butted away by the beetle every few seconds till 9 P. M. During the entire hour the coccid remained stationary and unresponsive, never once raising its caudal segments nor emitting a droplet. All this time the beetle had remained in the same spot and had butted every beetle or larva with which its antennæ had come in contact. The beetles soon left after receiving a few knocks but the little larvæ A and B, which seemed to be famished, persisted for a whole hour side by side, except for the 20 minutes during which A was absent. Larva B must have been struck by the beetle more than a hundred times. Finally the latter's patience seemed to be exhausted; it seized first A and then B in its mandibles, carried the latter three millimeters away from the coccid and hurled it to one side. Larva A returned, but B had fallen out of the petiolar cavity onto the moist wall of the glass tube, adhered and was unable to leave the surface. The beetle now left the coccid and another very mature beetle (No. 4) took its place. It permitted larva A to stroke the posterior end of the coccid without molestation, but beetle No. 3 soon bustled up from the opposite direction, locked mandibles with beetle No. 4 and pushed it away. During the scrimmage the coccid suddenly raised its caudal end and discharged a droplet which was eagerly inbibed by the larva, at length rewarded for its incredible pertinacity and the innumerable knocks it had received. Then beetle 3 and larva A, now in undisturbed possession of the coccid but in the reversed position, the former being at the anterior, the latter at the caudal end of the coccid, continued their stroking, interrupted every few seconds by the butting of the beetle and the temporary withdrawal of the larva. This went on till 9.20. By that time my eyes which had been following the performance under the lens for an hour and twenty minutes were so fatigued that I had to desist from further

observation, just after the beetle had tossed the larva to a distance of about four millimeters from the coccid by an unusually well-aimed blow.

Scenes of this description were so frequently enacted that they could be readily observed in almost any of the colonies after they had been kept for several days and the beetles, larvæ and coccids had all grown very thirsty. In such colonies the bodies of the coccids and larvæ become visibly attenuated and somewhat shrivelled as a result of the loss of water from the tissues of the *Tachigalia* petioles. All the insects now become restless. The beetles leave the petioles, wander about on the walls of the tubes and finally collect about the plugs of cotton in an endeavor to escape to the outside. The coccids, too, withdraw their beaks from the parenchyma in the floors of the food-grooves and wander aimlessly about, vainly seeking more favorable pastures. But before this stage of demoralization is reached, both the beetles and the larvæ become cannibalistic and one may often see them, singly or in groups voraciously devouring partly dismembered larvæ or immature beetles. Within a few days all the larvæ and immature beetles are consumed, but the coccids, immune from attack, still wander about till they die of starvation.

I believe that *Coccidotrophus* is rarely or never cannibalistic under normal conditions. It is, as already stated, almost impossible to split a freshly gathered *Tachigalia* petiole containing one of the beetle colonies, without cutting some of the insects in two, and such disabled individuals are soon devoured by their fellows, but both in such cases and in the cannibalism that supervenes in dried petioles, I believe that thirst or the need of water and not a veritable carnivorous instinct, such as seems to be manifested by some species of Cucujid beetles and their larvæ, must be regarded as the true explanation. I am confirmed in this view by Heins' recent investigations (1920) on meal-worms *(Tenebrio molitor)*. He found that when the larvæ of this beetle are reared in dry meal as many as 24.2% of them may be devoured by their fellows, but that if wet slices of rusk or of vegetables are placed in the breeding jars the mortality from cannibalism is reduced to 7.5%. In this connection Bodine's observations (1921) on grasshoppers are also of

interest. He finds that during starvation, the loss of water in these insects is always greater than that in body weight or in the solids. "This shows that starvation in the grasshopper results in a rapid loss in water which has a decidedly quick and fatal effect."

I have been unable to ascertain the length of the larval period or the number of larval moults of *Coccidotrophus*. As no exuviæ were found in the petioles it would seem that they must be devoured either by the beetles or by the larvæ themselves. The food of the larvæ, as we have seen, consists of the amber-colored nutritive parenchyma and of the sweet excreta of the coccids, the former evidently supplying the proteids, the latter the sugar and most of the water. So concentrated a diet should be very favorable for growth and probably the whole larval period at tropical temperatures occupies only two or three weeks. The fat-body, however, does not seem to become very voluminous till the last larval instar when the segments of the body become more convex and puffed out with the accumulations of adipocytes. Yet this condition, which immediately precedes pupation, does not tend greatly to inhibit the activities of the larva.

When a petiole containing a colony in what I have called the third stage is opened, one or more cocoons are invariably found in the cavity (Plate V). They are oblong-elliptical structures, 5-6 mm. long and 2-3 mm. broad and seem to consist of the same chocolate brown substance as the frass-ridges. Their walls are of uneven thickness, with smooth inner and roughened outer surfaces, and are easily fractured. These cocoons do not lie loosely in the cavity but are attached to some flattened surface of the wall where the lumen of the petiole is rather broad, i.e., away from the pointed ends, and always have their long axes parallel with the long axis of the cavity. They are sometimes single but more frequently occur in pairs or in groups of three or four. When in pairs, the two cocoons lie abreast of each other, when in threes or fours, the third and fourth cocoon are often built on top of a basal pair. Such groups of cocoons are so voluminous that they obstruct the lumen of the petiole and leave only a narrow passage for the beetles to move between the more roomy spaces at either end of them.

One naturally infers that either the larvæ must make the cocoons of frass or the beetles must envelop the pupæ with this material, but observation shows that both inferences are incorrect. The larva does, indeed, build the cocoon, but utilizes neither the frass nor the materials of old, abandoned cocoons in its construction. I have not seen the earliest stages in the process but it is evident that the larva selects a flat surface and begins to build a wall around an elliptical area, which thus becomes the floor of the cocoon. Little material is added to the wall at the end of the ellipse compared with the sides, where the material is built up as a pair of folds like those shown in Fig. 16*a*. I have seen several cocoons that had been abandoned in this or a somewhat more advanced stage, but on two occasions I was able to observe the completion of the structure from a stage like the one figured. Since in both cases the insects behaved in essentially the same manner I shall describe only one of them.

The larva was first seen working inside the cocoon in the stage of Fig. 6*a*, but it soon came out, wandered away to a distance of a few millimeters and, after careful search, bit off a minute particle of the living tissue of the petiolar wall, avoiding any frass-covered surface, returned, entered the cocoon at one end (left hand side of Fig. 6*a*), carefully masticated the particle with its maxillæ, while mixing it with saliva, applied it to the border of one of the folds, pressed it into place, crept out of the other end of the cocoon and went in search of another particle. Then it returned, entered the cocoon as before and repeated the building process. Excursions were made every few minutes and within a radius of 8 to 10 millimeters from the cocoon. The particles, which were selected with the greatest care and often after what seemed like some hesitation, were very minute and greenish when first bitten off but had become brown (by a process of oxydation?) by the time they had been incorporated in the walls of the cocoon. The particles were applied now to one fold of the wall, now to the other so that the edges became rather irregular (Fig. 6*b*), but as most of the particles were added to the middle of the folds, they began to approach each other. Still, their growth was very slow, owing to the minute size of the particles and the time consumed in their selection. The larva labored incessantly, making trip after trip and choos-

ing every particle with the same diligence and avoiding the remains of empty cocoons in the immediate vicinity, although their materials, one would suppose, might have been easily appropriated and quickly built into the cocoon under construction. The two folds or side-walls slowly approached as the work progressed and eventually fused with each other, the larva always entering at the same end, applying the particle to one of the edges from the inside and leaving by the opening at the opposite end. Then it set itself to building the walls around this latter opening, which grew smaller and smaller (Fig. 6*c*), till the larva could no longer squeeze through it and was compelled when about to leave the cocoon to turn back on itself, bending its body in a loop with the two limbs in contact, and crawl out of the opening by which it had entered. This feat seemed to be accomplished with considerable effort but had to be performed after each particle had been built into the wall of the cocoon. Eventually the small opening was closed and the cocoon had only a single large elliptical orifice at one end (Fig. 6*d*). The larva now began to contract this orifice, but after a time, as it grew smaller, the insect on returning, no longer entered the cocoon and reversed its body in order to apply the particles to the edge of the orifice, but merely thrust its head and a few of its anterior segments into the cocoon and left the remainder of its body outside. At such times it used as a support or fulcrum a structure which I had not seen used at any previous stage of larval life, namely, the proleg which terminates the conical tenth abdominal segment. This structure is described by Dr. Boving (Zoologica III, No. 7) and clearly shown in his figures (Pl. VII, figs 1 and 2). When the size of the orifice had been reduced till the larva could only just squeeze through it, the insect entered the cocoon, reversed its position and continued building along the edges of the orifice with particles scraped from the inner surface of the structure. The orifice thus soon grew too small to permit the egress of the builder. (Fig. 6*e*). Then the imprisoned creature slowly closed the opening and the cocoon was completed (Fig. 6*f*).

A few days after the larva has thus immured itself, it sheds its cuticle and becomes a pupa which lies loosely in the cavity of the cocoon and has the appearance of Dr. Böving's Plate IX, figs.

19-21. Owing to the minuteness of the particles used in building the cocoon, the care with which they are chosen and the many trips necessary to secure them, the time consumed in completing the structure is considerable. The earliest stage figured (Fig. 6*a*) was first seen at 8 P. M., July 25. By 6 A. M. the following morning the cocoon was in the stage shown in *b*. By 12.30 P. M. the small opening had been closed and the large opening was being contracted (*c*). At 6:30 P. M. a small opening remained (*e*), and the cocoon was completed an hour later (*f*). As the first stage must have been the work of the greater part of a day, the structure was probably begun not later than 7 A. M. on July 25th. At least 36 hours of continuous labor, requiring hundreds of trips back and forth between the cocoon and exposed patches of living parenchyma on the petiolar wall, were therefore consumed in completing the cocoon. The second larva observed in the act of building its cocoon was even slower, since the latter was first seen on the evening of July 26 in a stage corresponding to Fig. 6*a* and was not entirely completed till after 10 A. M., July 29th. There was nothing to indicate that the first larva rested during the whole period of cocoon construction. While it was working in the manner described, it was occasionally annoyed by some young or half-grown larva entering the cocoon and using it as a hiding place while its architect was away gathering building materials. It was interesting to see the latter on its return oust the intruder, which scampered away with comical alacrity. When the cocoon is completed it is rather smooth externally but may later become rough through the beetles' plastering their frass over its surface. This certainly strengthens the walls of the structure.

I endeavored to keep the two pupæ enclosed in the cocoons which I had seen built, in order to determine the length of the pupal period, but both died when the petioles dried out. The pupal period as inferred from other cases covers, at least, seven days. The callow emerging beetle under normal conditions gnaws a round or elliptical opening at one end of the cocoon and joins the other members of the colony. At first it is yellowish white and etiolated, with the legs, dorsal surface of head and prothorax and a transverse band on each segment of the venter pale red. It runs about very actively, nevertheless, and

in the course of several days gradually takes on the deep chestnut brown color of the mature insect. But before this stage is reached, and while the male and female are still of a bright red or pale chestnut red color, they mate. On two of the three occasions on which I witnessed copulation both the male and the female were immature. The third couple, observed August 10, consisted of an immature female and a mature male. It would seem, therefore, that mating occurs not only among immature beetles of the same generation soon after they leave the cocoons, but that old males of a preceding generation at least occasionally fecundate the recently emerged females.

The observation of August 10 is here transcribed from my note-book. The female was distinctly immature but uniformly red, i.e. no longer in the white, callow stage, and distinctly smaller and more slender than the male. The latter was certainly very nearly or quite mature. When first noticed the female was eating the parenchyma of the petiolar wall. The male mounted her back and remained for 18 minutes, clasping her sides with his legs and occasionally attempting to insert his aedoeagus. Now and then he rubbed her occiput from side to side with his mandibles and antennæ and sometimes shifted his position very much to one side. The antennal movements were precisely like those employed in titillating the coccids. The female kept on feeding and pressed the tip of her abdomen against the wall of the petiole so that the male was unable to introduce his aedoeagus. He then dismounted and ran away but soon returned and attempted to mount and grasp the female again, but she was unwilling, slipt out from under him and escaped. He permitted her to go only a very short distance, however, before he again seized her just as she had stumbled on a coccid and had begun to stroke its posterior segments. While the male was strenuously endeavoring to copulate she continued to stroke the coccid and on this occasion kept the tip of her abdomen tightly pressed upward against the tips of her elytra. Then the male again dismounted and left her and she and another immature beetle turned their attention to a partly eaten larva which they proceeded to devour. In a moment the male, apparently in a high state of excitement, returned, mounted the female and this time succeeded in introducing his ædoeagus by

forcing the tip of the female's abdomen downward and away from the tips of her elytra. During coitus, which lasted a little more than six minutes, the female continued to partake of the larva, but the male remained motionless.

B. The Enemies of the Beetles and Coccids and the Decay of the Colonies.

Attention has been called to the decay of the *Coccidotrophus* colonies when the flow of sap to the petioles is artificially cut off by severing the latter from the plant and both coccids and beetles are deprived of their nourishment. But even under the natural conditions of the jungle the colonies are doomed to decay, though from very different causes. As has been shown, *Coccidotrophus* lives only in the petioles of young Tachigalias growing in the shade and in these plants inhabits the petioles only till they are taken over by the obligate ants of the genera *Pseudomyrma* and *Azteca.* The beetles are not permitted, so to speak, to occupy their apartments after the rightful owners of the plant have become sufficiently numerous and aggressive to eject them. Sometimes this may occur even in rather young plants four to six feet in height. Still the period during which the beetles may be allowed to inhabit the young Tachigalias must cover several months. I infer this from the fact that during the more than two months of my stay at Kartabo I saw little change in the plants, which grew very slowly notwithstanding the almost daily, drenching rains, and their growth is probably almost *nil* during the dry season. Since the leaves are persistent, at least during the rainy months, there is ample time for the development of the beetle colonies, even if the growth of the larval broods and the coccids requires more than the three weeks above suggested. Throughout the latter part of July, August and the first half of September colonies were found in all stages, from those represented by a single pair of beetles to those comprising numerous beetles, larvæ, pupæ and herds of coccids. It would seem, therefore, that although the individual colony may live for only a few months, new colonies must be formed continually, at least during the rainy season, by emigration of pairs of young beetles from old colonies to other plants which have

attained a sufficient size, i.e. have produced at least three or four fully developed leaves.

Still neither the beetles nor the coccids are permitted to live in perfect security till the obligate ants take possession of their quarters. Where competition among insects is so very keen as it is in the Neotropical jungle it is not surprising to find that several predators and parasites are continually gaining access to the petioles and decimating or even completely destroying their occupants. The greatest enemy of the beetles is the small thief-ant *Solenopsis altinodis* Forel (See p. 48 and Zoologica III, No. 4, p. 154), and the coccids have at least three formidable enemies. All of these insects enter the petiole through the openings made by the beetles and must therefore elude their watchfulness. We should expect the beetles to keep one of their number constantly on guard at the entrance, but they are neither sufficiently constant in this behavior nor sufficiently discriminating to keep out all intruders. When the petioles are taken into the laboratory the beetles are often seen to remain for hours with their heads in the entrances and their bodies at right angles to the longitudinal axis of the cavity, and even after the petioles have been split longitudinally and placed in vials the insects still exhibit this behavior, though it is now absurdly futile, since their domicile is wide open. But not infrequently even the single opening of a petiole may remain unguarded for long periods, and when the petiole has several openings some of them are apt to have no sentinels, so that predators and parasites small enough to pass the narrow orifices, have no great difficulty in gaining access to the colony. Moreover, a beetle that is guarding an opening may fight off certain intruders but back away and allow others to enter. On several occasions I held a beetle with its head to a guarded entrance. The sentinel at once grasped the stranger's head with its mandibles and pushed it away. But when I placed a worker *Solenopsis altinodis* in the same position, the beetle beat a hasty retreat and the ant climbed into the petiole. From these experiments we may infer that the beetles are more intent on keeping alien beetles of their own species than dangerous pests like the *Solenopsis* out of their nests. More probably some peculiar odor of the ant induces the beetle to withdraw. Thus while it seems to be probable that alien

beetles are often kept out of the colony, the fact that the beetles of two or more colonies occupying different petioles, will, when the latter are split open and placed in the same tube, mingle without the slightest signs of hostility, would seem to show that even strange beetles may occasionally enter an unguarded colony and become members of it in good standing. It has since occurred to me that female beetles, at least, might be permitted to pass the sentinels unchallenged. Unfortunately I failed to dissect and determine the sex of the beetles with which I experimented.

The laxity of the beetles in guarding the entrances is, indeed, amply proved by the presence in their nests of several species of insects, some of which are harmless or indifferent while others are injurious either to the beetles and their larvæ or to the coccids. From analogy to the guests of ants, those of the former category may be called "synoeketes," or indifferently tolerated guests, the latter "synechthrans" (predators) and parasites. To the synoeketes belong a Collembolan, a mite and a small Phorid fly. The Collembolan is most frequently seen, especially in large petioles containing small colonies of beetles and therefore allowing ample space for its movements. It is a minute silver gray species, which Prof. Folsom has described and figured as *Entomobrya wheeleri* (Zoologica III, No. 11), and occurs in droves of individuals of all stages, running hither and thither over the walls of the petiole, like certain species of the same genus (*E. myrmecophila* Reut. and *dissimilis* Mon.) and *Cyphodeirus* (*C. albinos* Nicol), which are often abundant in the nests of ants. Like the ants the *Coccidotrophus* pay no attention to these diminutive insects and are probably not even aware of their existence. The mites (*Hypoaspis* sp.) and Phorid flies (*Aphiochæta scalaris*) were more rarely seen. They probably breed in the accumulations of refuse at the ends of the petiolar cavity and may therefore be regarded as scavengers, like the mites and Phorids which occur in many ant-nests.

Careful examination of the alimentary tract of the *Coccidotrophus* would probably show that the beetle harbors a number of entoparasites, at least certain bacteria, but I could not find the time to make such an examination when fresh material was available and my alcoholic specimens are worthless for the purpose.

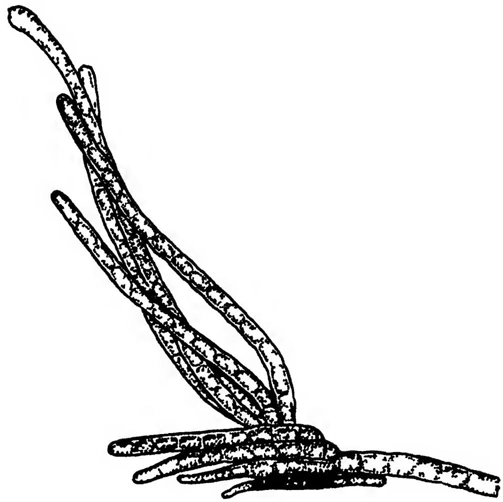


FIG 12 HYPHOMYCETOUS PARASITE ON *COCCIDOTROPHUS SOCIALIS*
From a drawing by Prof Roland Thaxter

It seemed probable, nevertheless, that the beetle, living as it does in dark, moist cavities, might be infested with ectoparasitic fungi, especially of the group Laboulbeniales. I therefore requested Prof. R. Thaxter, the leading specialist in this group, to examine a large number of the beetles. After carefully scrutinizing their external surfaces he reports that he found no Laboulbeniales, but only a sterile Hyphomycete, growing on the elytron of one of the specimens. Referring to his work on the similar fungi of other insects he writes me as follows: "The fungus on the *Coccidotrophus* probably belongs to the group spoken of at the bottom of p. 237 in my first paper (1914), the most striking form of which (*Aposporella elegans* Thaxter), found on the wings of a small fly from the Kamerun, is figured on Plate III, Fig. 30 of the second paper (1920). These fungi seem to produce no spores and to reproduce by a kind of fragmentation; pieces breaking off with little or no differentiation, and starting to grow where they adhere. I have seen a considerable number of them on a variety of tropical insects, and ran across one of them a few days ago growing on a *Laboulbenia* from Kamerun. It has seemed hardly desirable to give names to such nondescript

forms till it is quite certain that they have no differentiated type of reproduction." Prof. Thaxter kindly enclosed a drawing of the *Coccidotrophus* Hyphomycete which is here reproduced as Fig. 12.

The various organisms just described can, of course, have little or no effect on the health of the beetle colonies. Their decay and eventual extinction is due to ants destroying the beetles and their larvæ or to predators or parasites destroying the coccids on which they depend for an important part of their diet. Colonies in all stages may be invaded by the tiny *Solenopsis altinodis,* which I believe to be the most persistent and deadly enemy of the beetles. I have opened petioles containing both beetles and *Solenopsis* workers, but no beetle larvæ or only fragments of them, showing that the ants begin their depredations by slaughtering the offspring of the beetles. In such petioles the coccids remain uninjured, and the same is true of the pupæ immured in their cocoons. Many other petioles reveal conditions from which the last stages in the history of the colony may be inferred. In such petioles only dead beetles and a number of dead *Solenopsis* are found, indicating that the ants, after destroying all the larvæ, attack the beetles and that they, in the ensuing bitter conflict, often defend themselves with their powerful jaws to such good purpose that they succeed in killing many of the ants. But as more *Solenopsis* are probably continually entering the petioles as auxiliaries the beetles finally succumb and the colony is exterminated, with the exception of such pupæ as may be present in their protective cocoons. The beetles emerging from these may, conceivably, after the *Solenopsis* invasion is over, start a new colony in the same petiole or emigrate to other petioles. If no pupæ are present the petiole is sooner or later entered by a pair of young migrant beetles, which pack the dead bodies of the previous occupants, together with the ants they have slain, into the ends of the cavity and establish a new colony. In some of the colonies in the last stages of devastation above described, I failed to find any coccids. They may have been either eaten or carried away by the *Solenopsis.* Sometimes they remain undisturbed, however, and may, perhaps, be taken over by the beetles emerging from the cocoons or by any pair of young beetles entering the petiole and establishing a new colony.

We can picture to ourselves the fierce battles which rage in the petioles between the beetles and the *Solenopsis* workers, probably mostly at night, for the *Solenopsis* is a nocturnal species, and the precarious life of the beetles in parts of the jungle where the ant is abundant. The beetles must live, in fact, like the ancient Greeks, always in danger of invasion from the warlike hords of barbarians. Yet even in quiet recesses of the jungle, where the *Solenopsis* may happen to be rare or absent, the attachment of the *Coccidotrophus* colonies to the *Tachigalia* is sure to be severed as the plant grows and the workers of the colonies started in one or more of the petioles by deälated queens of *Azteca* or *Pseudomyrma* have become sufficiently numerous to take possession of every petiolar cavity and patrol the whole surface of the plant. Perhaps some of the inquiline ants may occasionally kill or oust the beetles, but as these ants merely occupy a petiole here or there on the young trees, they cannot be regarded as very serious enemies. Many of them, too, are small, timid ants, which probably have their own battles to fight with the insidious *Solenopsis* and are destined to be supplanted, like the beetles, by the obligate Pseudomyrmas and Aztecas.

During the struggles between the beetles on the one hand and the *Solenopsis, Pseudomyrmas,* and *Aztecas* on the other, the poor coccids evidently play somewhat the same defenceless rôle as the cattle in a country overrun by contending armies—they merely change masters and are either eaten, or carried off or permitted to remain and produce honey-dew for the victors. But before any such change of masters occurs they are often decimated or even exterminated by three enemies of their own, which may be briefly described *seriatim.*

In a few of the beetle colonies I have seen a number of larvæ of a very small Coccinellid beetle, described by Schwarz and Barber as *Scymnus xantholeucus* (Zoologica III, No. 6). These larvæ when full-grown resemble the larger coccids so closely in size, form and color and are covered with such a similar layer of snow-white wax, that I frequently overlooked them in my living colonies and detected their presence only in the preserved material after my return to the United States. They move slowly about among the beetles and their larvæ and devour the coccids. I am inclined to believe that by the time they are ready to pupate,

they have also devoured all the beetle larvæ since I found two petioles each containing nothing but a pair of *Scymnus* pupæ, a few shrivelled remains of coccids and the kitchen-middens at the ends of the cavity. The pupæ were attached to the wall by their caudal ends and with their longitudinal axis parallel with that of the petiole. They were of a waxy yellow color, with their surface studded with short, blunt hairs. Several days later the imaginal beetles emerged. They measured 1.7 mm. in length and 1.2 mm. in width and were pale yellow, with the basal two-thirds of the elytra, the meso- and metasternum and the median third of the first and second abdominal segments fuscous.

A much more abundant enemy of the the coccids is a peculiar predacious Itonidid (Cecidomyid) fly, which Dr. Felt has described as *Diadiplosis pseudococci* (Zoologica III, No. 8). The larvæ of this insect are orange red and are often found in clusters of as many as eight to a dozen around groups of coccids. The whole mass is covered by a tough, dense, white web, or tent, which is spun by the larvæ in such a way as to shut them and the coccids off from the cavity of the petiole and therefore from contact with the beetles or their larvæ. Thus secure from interference the *Diadiplosis* larvæ devour the coccids at their leisure, attacking them from the ventral side where their integument is thinest and free from wax. The coccids are eventually reduced to their dorsal integument. When mature the *Diadiplosis* larva pupates where it has been feeding, often in the midst of a group of young or full-grown larvæ, and without orienting itself with respect to the longitudinal axis of the petiole. Just before eclosion the pupa forces its body, head foremost, through the silken tent and projects into the cavity. The fly then emerges and probably either lays its eggs among any surviving coccids or emigrates from the petiole and enters other beetle colonies. The adult fly is a very delicate little midge measuring only 1.25 to 1.5 mm. and of a reddish-brown color, with the abdomen red internally and the sclerites somewhat infuscated.

Considerable interest attaches to this insect, because, unlike the great majority of Itonidids and the species noticed above (p.50), it does not make plant galls but is predaceous. The genus *Diadiplosis* was originally established by Felt (1911a), for *D. cocci* Felt, a species reared in the island of St. Vincent from larvæ preying

on the eggs of a coccid, *Saissetia nigra* Nietn., on stems of Sea Island cotton. In another paper published during the same year (1911b) he gives a list of 19 species of known zoophagous American Itonidids. The list includes species of *Endaphis, Arthrocnodax* and *Mycodiplosis* feeding on mites, an unidentified species of *Cecidomyia* feeding on the eggs of *Cicada septemdecim,* several species of *Aphidoletes* and *Lestodiplosis* preying on aphids and of *Lestodiplosis, Dentifibula, Diadiplosis, Coccidomyia, Cecidomyia, Lobodiplosis, Mycodiplosis* and *Dichrodiplosis* preying on various coccids. The *Diadiplosis* from British Guiana seems to be closely related to the type of its genus. According to Küster (1911), certain European Itonidid larvæ have been described by Rübsamen (1899) and Kieffer (1902) as preying on the larvæ of gall-makers of the same family.

Almost as abundant as the *Diadiplosis* in the beetle colonies is a Hymenopterous parasite of the *Pseudococcus,* namely *Blepyrus tachigaliæ* Brues (Zoologica III, No. 9), a small Encyrtid of the family Chalcididæ. The white larva of this insect lives in the coccid and grows with it, eventually becoming so voluminous that the coccid's body is very convex both dorsally and ventrally. The coccid grows increasingly sluggish and inert and its wax-glands cease to function so that its integument takes on a dull brownish color and the wax-pencils disappear from its periphery. The beetles and their larvæ are, of course, quite unaware of these profound changes in their parasitized cattle and still continue to stroke them, often for long periods, although there is no honeydew forthcoming as a reward for their efforts.

When full-grown the larval *Blepyrus* does not escape from the coccid but remains within it and forms an amber-colored, regularly elliptical cocoon about 2 mm. long and therefore very nearly as large as the coccid, which is now reduced to a mere skin enveloping the huge parasite. The cocoon seems to consist of a hard, glassy substance, possibly a modified silk, and is covered except on its ventral side with small circular spots which represent thinner, depressed areoles in its wall. Where these areoles are lacking on the ventral side the wall is homogeneous and distinctly thinner than elsewhere, but has a number of small pointed projections which seem to pierce the ventral integument of the coccid and to attach the cocoon rather firmly to the wall of

the petiole. Since the parasitized coccid remains in the food-groove with its body in the usual position the cocoon necessarily has the same position and orientation, i.e. with its long axis parallel with the long axis of the petiole. The cocoon gradually grows darker, passing from amber-yellow to dark brown and by the time it has reached this stage, the dead tissues of the coccid enveloping it, except those on the ventral side, between the cocoon and the wall of the petiole, disappear, leaving the lateral and dorsal surfaces of the cocoon fully exposed. I am inclined to believe that the dead tissues of the coccid are eaten away by the beetles or their larvæ, but as they are very soft and disintegrate easily, they may perhaps be rubbed off merely by the attrition of the insects as they move back and forth in the petiole. Two of the denuded cocoons in the stage and with the orientation just described are shown in Fig. 11.

When the completed *Blepyrus* cocoon is cleared in carbol-xylol, mounted in balsam and examined as a transparent object, the larva is found to have pupated within it, after extruding a number of large meconial pellets, the undigested remains of all the food it swallowed while it was living on the tissues of its host. In most cases, at least, the head of the pupa is at the caudal end of the coccid. The imago, when mature, cuts a large round hole in the end of the cocoon (see upper part of Fig. 11) and emerges as a short, thickset, broad-headed fly, only 1.5 mm. long, with a metallic green face, a black, more or less bronzed body, black and yellow antennæ and legs and basally infuscated wings. It is very active, and like other small Encyrtids skips about by using the long saltatory spurs on its middle tibiæ. After mating the female undoubtedly oviposits in the young coccids either in the same or in some other beetle-inhabited petiole.

This parasite seems not to be nearly so serious a menace to the *Coccidotrophus* colonies as the *Scymnus* and *Diadiplosis*, since the infested coccids are probably able to supply the beetles and their larvæ with honey-dew till both host and parasite are nearly mature. Hence one often finds several infested coccids and *Blepyrus* cocoons in petioles inhabited by flourishing beetle colonies. In one such colony I counted more than fifty cocoons and a dozen large coccids swollen with parasites that were still in the larval stage.

I have failed to find more than one of the three species of coccid enemies in a single petiole. Their combined action, if they actually ever occur together, would, of course, not only greatly hasten the extermination of the coccids, but would seriously interfere with their own development. It may be noted incidentally that none of these enemies occurs in the petioles of the large Tachigalias inhabited by the obligate Pseudomyrmas and Aztecas. In such plants the coccids are free from all predators and parasites and are not only more numerous but attain a larger size than in the petioles of the small shade trees tenanted by the *Coccidotrophus*. The ants are undoubtedly much more efficient than the beetles in keeping small miscellaneous guests and synoeketes out of their nests. This is particularly true of the Pseudomyrmas. Although I have collected the entire colonies of many of these ants on several different trips to the American tropics, the only synoekete I have ever seen associated with them was a *Microdon* larva described many years ago (1901) from the nest of *Pseudomyrma mexicana* Roger. Even coccids are kept and attended by only a few species of *Pseudomyrma*.

Before concluding my account of *Coccidotrophus* I may introduce a few statistical data, which are probably valid only for the particular time and locality of my observations. While at the Tropical Laboratory I noted roughly the condition of the contents of each of the *Tachigalia* petioles I opened on a particular day. On some days only a few petioles were opened and the results are not worth transcribing. The following collection, however, gives a more interesting picture owing to the number of petioles examined:

August 9. Collected 253 petioles from young Tachigalias 1½ to 7 ft. high growing along the Cuyuni Trail. Of these 37 or about 14% were either too young to have inhabitants or contained solitary *Pseudomyrma* queens founding colonies or small colonies of inquiline ants; 203 or about 86% either contained or had contained beetle colonies. Of the latter number, 50 contained incipient colonies, i.e., a single pair of beetles or more rarely single beetles which had just entered the petioles and were busy "cleaning house." In one petiole one of the beetles of a pair was guarding the entrance while the other was shovelling frass and the remains of previous occupants with the top of its head into

the pointed ends of the cavity. Sixty-four of the beetle colonies had larvæ and were in what I have called the second and third stages. In nearly every case coccids were seen. Eighty-nine of the colonies were either moribund or extinct. *Solenopsis altinodis* workers either living or dead, were present, sometimes in considerable numbers, in 35 of these petioles, and 10 of them still contained large coccids that had been shut off by webs and were being devoured or had been already devoured by *Diadiplosis* larvæ. In one petiole two of the flies had emerged. In 6 of these petioles the *Solenopsis* workers had destroyed the beetles and their larvæ and were still running about. When I tore away the webs covering the *Diadiplosis* larvæ the ants at once seized and killed them. The webs serve, therefore, not only to protect the Itonidids from the beetles and their larvæ, but also from the *Solenopsis*.

C. Eunausibius wheeleri Schwarz and Barber.

This beetle, though superficially very similar to *Coccidotrophus socialis*, can be easily distinguished in all its postembryonic stages. The adult beetle (Plate III, fig. 1, Plate VI, figs. 6 to 10) is distinctly smaller, measuring only 3-3.5 mm., permanently of a red color like the immature *Coccidotrophus* and therefore never deepening into the dark chestnut color of the latter. The antennal clubs are larger and broader and much more distinctly marked off from the more proximal joints, the eyes are much larger, the anterior border of the front is much less deeply emarginate, the femora are less incrassated and the posterior pair has a small tooth on the flexor side. The surface of the body is smoother, the punctation being less pronounced. The larva is more slender, with the head and dorsal surface distinctly gray, owing to a deposition of fine pigment granules in the integument. The pupa can be at once recognized by the presence of four large, equidistant tubercles on each of the parallel lateral borders of the pronotum (Fig. 8*a*, Plate IX, fig. 23). For many of the less obvious differences between the various instars of the two beetles the reader may be referred to the excellent descriptions and figures of Schwarz and Barber (Zoologica III, No. 6) and Boving (Zoologica III, No. 7).

The prominent tubercles on the sides of the pupal pronotum of *Eunausibius* merit somewhat fuller consideration, because they present a striking instance of the retention in an earlier ontogenetic stage of a character which may be completely lost in the adult. An examination of the common saw-toothed grain-beetle, *Oryzæphilus* (formerly *Silvanus*) *surinamensis* L., represented in Fig. 7, and other species of the same genus, shows that the adult beetle has six acute teeth on each of the lateral borders of the pronotum, corresponding to and arising within as many large, blunt tubercles of the pupa. These structures were long ago noticed by Coquerel (1849) and Perris (1852) and by the former erroneously supposed to be portions of some tracheal system peculiar to the pupa. In *Nausibius* (*N. clavicornis*) the pronotum of the beetle bears six obtuse teeth on each side. In other Silvanid genera, such as *Silvanus* and *Cathartus* as well as in *Eunausibius* and *Coccidotrophus* these teeth are either altogether absent in the imago, or reduced to the first pair, which form the anterior corners of the thorax. *Eunausibius* has well-developed teeth in this position but in *Coccidotrophus* the anterior corners of the pronotum are merely rectangular. It is therefore interesting to find that the pupa of *Eunausibius* has four well-developed pairs and a fifth vestigial pair of tubercles, that these tubercles decrease in size anteroposteriorly, and that only the first pair gives rise to teeth that persist in the adult. In *Coccidotrophus* the reduction of the pupal tubercles is carried much further since there are only small vestiges of the three anterior parts of *Eunausibius*, none of which gives rise to teeth in the imago. Moreover, the second and third pairs of pupal tubercles may be represented by only a single tubercle on one side of the pronotum, as Böving observed (Zoologica III, No. 7). The tubercles are, in fact, so evanescent that they have become very variable, like vestigial organs in general. This is seen in Fig. 8—*b* to *f*, representing the prothoraces of five *Coccidotrophus* pupæ selected from a series of fifty specimens. We may safely conclude, therefore, first, that *Eunausibius* and *Coccidotrophus* are derived from ancestors which had a 12-toothed pronotum like the species of *Oryzaephilus;* second that this condition disappeared first in the imago and still tends to linger on in the pupa, and third, that the tubercles have a tendency to disappear in sequence in a posteroanter-

ior direction. There can be little doubt that the dentation of the sides of the thorax is a very ancient character not only in the Silvanids but also in the Cucujids (as restricted by Böving), since vestiges of the teeth can also be clearly seen in the imagines of certain genera of the latter family (*Cucujus, Brontes*).

I have already alluded to the fact that *Eunausibius* colonies are much rarer at Kartabo than those of *Coccidotrophus* though both species may occur in the same localities and even in different petioles of the same young *Tachigalia.* And not only are all the instars of *Eunausibius* smaller than those of *Coccidotrophus* but the colonies are also much less populous. The largest I have seen consisted of less than a dozen beetles and not more than two dozen larvæ. The habits, so far as I have been able to observe them, are much like those of *Coccidotrophus.* The *Eunausibius* also feed on the nutritive parenchyma in the walls of the petiole but they do not dig long grooves in the tissue but only narrow elongate pits, nor do they build up their frass in parallel or vermiculate ridges but plaster it in a thin layer over the walls of the petiole, so that the latter are smooth and even. The elongate entrance to the petiole seems not to be provided with a wall of frass. In one petiole I found that the pair of parental beetles had entered through a large hole about 2.5 mm. in diameter which had evidently been made by some larger insect. The beetles had plugged the opening with frass, leaving a small elliptical opening in the center just large enough to fit the head of the beetle when acting as a sentinel. Coccids are found in the elongated pits in the nutritive tissue but are few in number and of small size, though the *Eunausibius* solicit and drink their saccharine excretions in the same manner as *Coccidotrophus.* The cocoons of *Eunausibius,* apart from their smaller size and somewhat more delicate walls, are very much like those of *Coccidotrophus* and are, in all probability, constructed in the same manner.

I have seen so few colonies of *Eunausibius* that I can give no account of its enemies nor of those of its coccids. In all probability it is even less able than the more vigorous and more prolific *Coccidotrophus* to withstand the insidious attacks of *Solenopsis altinodis.* The whole appearance of the beetle and its colon-

ies is that of a feeble, anæmic and harried species on the verge of extinction.

General Considerations

The behavior of the social Silvanids described in the preceding pages and the conditions under which they live are sufficiently startling to stimulate reflection and a comparison with other species of the same and allied families. Such comparison, as an ethological method, has so often thrown light on what appeared at first sight to be unique and incomprehensible instincts and their settings that we may hope by resorting to it to trace the peculiar conditions in *Coccidotrophus* and *Eunausibius* to simpler and more general phenomena. Since both the setting, or environment and the responses, or behavior of the beetles are rather complicated it will be best to consider them separately and to begin with the setting, i.e. with the *Tachigalia* biocoenose.

The general ethological concept of the 'biocoenose' was, of course, more or less clearly recognized by many of the early zoologists. Although the term seems to have been first used by Möbius (1877), even Rèaumur had an inkling of the value of studying insects in association with their host plants. He says: "I would that the observers who busy themselves with the history of insects gave catalogues of those that feed on every plant." In the middle of the last century Perris (1852-1862) devoted many years to the study of the insects associated with the maritime pine and the chestnut in France, and Kaltenbach (1874) attempted to list all the phytophagous insects of Germany according to their host plants. In the United States Packard's volume (1881) on the forest and shade-tree insects and Mrs. Dimmock's paper (1885) on the insects of the birch represent more modest studies of the same kind. Perhaps none of our entomologists has been more thoroughly convinced of the advantages of studying insects and other animals as components of biocoenotic complexes than Forbes. Forty years ago he expressed his general convictions on this subject in his paper on the food of fishes and insects (1880) and he has returned to the subject in a recent address (1915). His fine papers on the strawberry and maize plants and their associated organisms (1884, 1894-1905) also clearly illustrate the great value of biocoenotic investigations.

Picard (1919) has recently published an interesting paper on the insects of the fig in Southern France.

As a mere record of the insects associated with a tropical plant my study of the *Tachigalia* biocoenose is necessarily fragmentary, owing to the few weeks I could devote to it, but it acquires considerable interest from the fact that the *Tachigalia* is a myrmecophyte, or one of those plants which are supposed to be peculiarly adapted structurally to association with battalions of protecting ants. The only organs which can be cited, however, as such an adaptation are the fusiform enlargements of the petioles, which undoubtedly furnish excellent lodgings for all the various ants, both inquiline and obligate. The plant is utilized also as a source of food by the obligate species through the instrumentality of the coccids, which are kept in the petioles and draw their food by preference from the strands of nutritive parenchyma. The beetles also use the petioles as lodgings and not only utilize the species of coccid as a copious source of sugar and water but also feed directly on the tissues of the plant. The plant is therefore more completely exploited by the beetles than by the ants and might be said to be more perfectly adapted to the former than to the latter. But the question as to whether the peculiar structure of the petiole is really an adaptation to either of these groups of insects is one which I shall leave to the botanist. Prof. Bailey will no doubt deal with it in connection with the same problem in the other South American myrmecophytes which he has investigated. That both the ants and the beetles have adapted themselves to the plant cannot be doubted and this adaptation, as I have shown, is exhibited in three degrees, the inquiline ants merely using the petiolar enlargements as lodgings, the obligate ants as lodgings and through their herds of coccids as indirect sources of food, and the beetles as lodgings and as both direct and indirect sources of nutriment.

Of course, a particular biocoenose is not an isolated, perfectly self-contained association of organisms but shares some of its components with other biocoenoses. Thus the *Tachigalia* is part of a large association, or biocoenose of jungle trees growing under certain conditions of soil, humidity, light, temperature, etc. The *Atta cephalotes,* which occasionally defoliates the young tree is the center of an elaborate biocoenose of its own,

comprising all the trees it habitually defoliates, its fungus gardens, its myrmecophiles of the Blattid genus *Attaphila*, the toads, lizards and ant-eaters which feed on the foraging workers, the Amphisbaenians which live in the penetralia of the huge nests, etc. The two ants, *Camponotus femoratus* and *Crematogaster parabiotica*, which attend Membracids on the young shoots of the *Tachigalia*, are really characteristic members of the very peculiar "ant-garden" biocoenose, which I have described in another paper (1921), and the *Dolichoderus attelaboides* belongs to still another biocoenose of which many Melastomaceous plants and their Membracid parasites are important components.

A particular biocoenose must also, of course, have a phylogenetic history, i.e. we must conceive it to have been gradually built up, integrated and organized in time from components which detached themselves from other biocoenoses and attached themselves as satellites to an organism which furnished more congenial conditions of life. Owing to the basic nutritive interdependance of animals and plants, a particularly favorable plant usually constitutes the primary focus of a biocoenose. The various parasites, scavengers and synoeketes, which live with the insects that immediately depend on this plant merely use the former as so many secondary or tertiary foci. Thus in the *Tachigalia* biocoenose the primary focus is the young plant and the center of the focus the leaf-petiole, the secondary focus is represented by the coccids and the tertiary foci by the ants and beetles to the extent that they attract predators, parasites and scavengers.

It is permissible, perhaps, to reconstruct the phylogenetic sequences of the various organisms that have become associated to form the *Tachigalia* biocoenose. Not improbably the tree, like many other trees of the Neotropical jungle, was originally peopled throughout its life by a certain number of miscellaneous, inquiline ants. Among these were several species of *Pseudomyrma* and *Azteca*, both large genera comprising numerous forms which still habitually inhabit any available hollow twigs or petioles of the most diverse trees and shrubs. Later the number of these ants was reduced, through the advent of the coccids and their definitive association with the *Tachigalia*, to a very few species, the putative ancestors of the present *Ps. damnosa* and

maligna and *A. foveiceps,* because the coccids enabled them to acquire very intimate trophic relations to the plant. The coccids present an unsolved problem in this connection. It would seem that the *Tachigalia* must be their true host-plant, and that the various other plants on which they are known to live, are subsequent, or secondary hosts, possibly acquired when the natives of British Guiana and of the surrounding countries took to making clearings in the jungle and growing in them various introduced plants such as pine-apples, *Hibiscus,* etc. The truth of this statement can, of course, be established only by further investigation of *Pseudococcus bromeliæ* throughout its range. When the obligatory ants had thus acquired their definitive attachment to the tree, the miscellaneous inquilines necessarily became restricted to its youngest stages since they were no longer able to compete with the obligates for the possession of nesting sites on the adult plant. The Silvanid beetles were probably relatively late intruders which found that they could inhabit the young tree for a considerable period before the queens of the obligate ants had succeeded in maturing their broods of belligerent workers. At first the beetles merely used the petiolar cavities as lodgings and fed on the nutritive parenchyma in their walls, but later they discovered the coccids and learned how to obtain their honey dew and came to depend more and more on this saccharine nutriment. The various parasites, scavengers, etc., which infest the beetle colonies and their droves of coccids obviously represent still more recent accessions to the biocoenose. The other insects, such as *Atta cephalotes,* the Membracids and their attendant ants, the caterpillars and gall-flies of the leaves, etc., may belong to the ancient miscellaneous fauna which originally attacked or frequented the *Tachigalia* in all its stages, when it was quite as "unprotected" as the great majority of jungle plants.

Turning now to a consideration of the beetles themselves, it would seem to be desirable to review their activities in the light of what is known concerning the other members of the natural family to which they belong. Here, however, we encounter difficulties, for the family Cucujidæ (*sensu lato*) has been more neglected by taxonomists and students of insect behavior alike than any other family of equal size in the order Coleoptera.

As understood by Coleopterists the family Cucujidæ belongs to the huge and very inadequately analyzed Clavicorn complex of families, but its characters are so striking that they have arrested the attention of some of the specialists. Thus Leconte and Horn (1883) long ago remarked: "This family is evidently an antique and synthetic type, which exhibits alliances with both Heteromera and Rhynchophora more than any other Clavicorn family." And Handlirsch (1908) says: "The family Cucujidæ, which Ganglbaur places in the midst of typically Clavicorn forms, exhibits many primitive characters and at the same time high specialization. I do not believe that their antennæ can be derived from those of the Clavicorn type, although the Cucujids agree with this group in the number of their Malpighian tubules (six). Perhaps the Cucujids branched off very near the base from the Cantharid stem, but possibly, and I regard this as more probable, they form an independent series." In his phyletic tree (opposite p. 1278), Handlirsch therefore depicts the family as arising from the Protopolyphaga as far back as the beginning of the Coenozoic. Several species of *Silvanus* and one of *Passandra* are, in fact, known from the Baltic Amber (Lower Oligocene Tertiary), and Wickham (1920) cites *Laemophloeus vestitus* Scudder from the Green River Eocene and three species of *Lithocoryne* and a *Pediacus* from the Miocene of Florissant. That the family must be an old one is indicated also by the fact that New Zealand possesses some 20 indigenous species of Cucujidæ, distributed over 12 genera, mostly peculiar to the islands, which are said to have been separated from Australia during the Jurassic.

Kolbe (1910) is also of the opinion that the Cucujids are a primitive group. He says: "The very lowly organized Cucujids are not only in part characterized by a prothorax of very primitive structure (as in the Adephaga) but primitively inserted (inframarginal) and primitively constructed (filiform or moniliform) antennæ." Leng (1920) places the Cucujids in the lower portion of the series of Clavicorn families, near the Rhizophagidæ and Erotylidæ. In a brief study of the larvæ of Cucujids, de Peyerimhoff (1902-'03) calls attention to their great diversity and their resemblance on the one hand to the larvæ of *Cryptophagus* among the Clavicorns and on the other to *Pyro-*

chroa among the Heteromera. Hamilton (1886) long ago noticed the resemblance of the larval *Cucujus clavipes* to the Pyrochroid *Dendroides canadensis* larva. As shown in his very valuable paper on the larvæ of *Coccidotrophus* and other genera (Zoologica III, No. 7) Böving divides the Cucujidæ *auctorum* into four families, the Silvanidæ, Cucujidæ (*sens. str.*), Læmophlœidæ and Scalariidæ. The last of these he relegates to the group Cleroidea, and states that they are closely connected with the family Bothioderidæ of Craighead (1920).

Apart from several species of considerable economic importance, the little that is known concerning the habits of these four families of beetles is scattered through the literature. Such data as I have been able to glean in regard to the European, North American and cosmopolitan species have been brought together in condensed form in Zoologica III, No. 5. From these data it will be seen that the Cucujids, taken as a whole, exhibit certain tendencies which are not without significance in connection with the peculiar behavior of *Coccidotrophus* and *Eunausibius*. If we exclude the Scalariidæ, which Fiske (1905) has shown to be parasitic in their larval stages—resembling in this respect the Bothrioderidæ—we notice that the various genera and many of the species of the remaining families show an extraordinary diversity, one might say versatility of behavior. They occur in a great variety of habitats such as stored human foods of vegetable origin, under bark, in decaying wood, in the burrows of bark-beetles, under dead leaves and rubbish, and feed on all sorts of substances mainly of a vegetable and especially of a concentrated or highly nutritious character. Many of the species are scavengers, others are undoubtedly predaceous and prey on the larvæ of other insects. The adult beetles seem to be rather long-lived and usually, if not always, live gregariously with their larvæ, all the active stages feeding on the same substances. The developmental period is certainly very brief in some species, as e.g. in *Cathartus advena,* the whole life-cycle of which, from the egg to the imago may require only three weeks and in the saw-toothed grain beetle *(Oryzæphilus surinamensis)* less than a month. As a rule both the beetles and the larvæ of the vegetarian and detritivorous species are very tolerant of the presence of other insects and actually seem to seek their compan-

ionship, especially when the food supply is abundant. Thus *O. surinamensis* is often found living with the rice weevil (*Calandra oryzæ*), *Cathartus advena* with the Indian meal moth (*Plodia interpunctella*) and *O. mercator* with a Tenebrionid grain-beetle, *Palorus subdepressus.* Many of the species of *Læmophloeus* constantly live in the burrows of Scolytid beetles and feed on their dejecta. Owing to these peculiarities and especially to their very diverse and plastic feeding habits many of the Silvanids and Læmophloeids have become cosmopolitan household pests capable of doing considerable damage to many of the staple stored foods of our own species.

If with this general complex of behavioristic tendencies exhibited by the European and North American Cucujids (*sens. lat.*) we compare the activities of *Coccidotrophus* and *Eunausibius*, we find that the latter while retaining many of the ancient and primitive family traits nevertheless exhibit several of them in a peculiar and highly specialized form. Thus the merely gregarious habits of the adults and larvæ of the northern and cosmopolitan Cucujids have become more definitely social in the *Tachigalia* beetles, and their toleration of alien insects has increased; the feeding of the ancient Cucujids on various vegetable substances has become specialized to the point of concentration on a particular tissue of a particular plant and both adult beetles and larvæ have become coccidophilous. The construction of the cocoon, too, exhibits peculiarities not found in any other Cucujids. Owing to the unusual interest of these various specializations they may be discussed at greater length under separate captions.

1. Social Life Among the Coleoptera

If we regard as truly social only those insects in which the parent or parents live with their offspring, protect them and either feed them directly or prepare materials for their sustenance, there seem to be only three groups of beetles that meet these requirements, namely, the Platypodidæ, the Scolytidæ (Ipidæ) and the Passalidæ. The Platypodidæ and that portion of the family Scolytidæ, comprising, according to Hagedorn (1910) the tribes Corythalinæ, Xyleborinæ and Spongiocerinæ, with some 400 described species, mostly tropical, are commonly known as

ambrosia beetles, because like the Attiine ants of the Neotropical Region and many Old World termites they cultivate fungi as food for themselves and their larvæ. The remarkable social organization and the food-fungi of these beetles have been studied by Eichhoff (1881), Hubbard (1897a, 1897b), Hopkins (1898), Neger (1908a, 1908b, 1909, 1911), Schneider-Orelli (1911a, 1911b, 1912, 1913) and others, Hubbard's account of the habits of *Platypus compositus* of our Southern States is so interesting that I quote it at length:

"These social instincts reach their highest development, apparently in the genus *Platypus*. The species of this genus are readily known by their very long cylindrical bodies, their prominent head, flattened in front, the flattened and spur-tipped joint of the front legs, and in the males the spine-like projections of the wing cases behind. They are powerful excavators, generally selecting the trunks of large trees and driving their galleries deep into the heartwood. The female is frequently accompanied by several males, and as they are savage fighters fierce sexual contests take place, as a result of which the galleries are often strewn with the fragments of the vanquished. The projecting spines at the end of the wing cases are very effective weapons in these fights. With their aid a beetle attacked in the rear can make a good defence and frequently by a lucky stroke is able to dislocate the outstretched neck of his enemy. The females produce from one hundred to two hundred elongate-oval pearly white eggs, which they deposit in clusters of ten or twelve in the galleries. The young require five or six weeks for their development. They wander freely about in the passages and feed in company upon the ambrosia which grows here and there upon the walls. The chitinous ridges upon the thoracic segments, together with the row of tubercles upon the other segments, enable the larva to move as rapidly through the galleries as if it were possessed of well-formed legs. The mouthparts of the larva are also provided with strong cutting mandibles, but the inner jaws are not adapted to masticating hard food, such as particles of wood. The older larvæ assist in excavating the galleries, but they do not eat or swallow the wood. The larvæ of all ages are surprisingly alert, active and intelligent. They exhibit curiosity equally with the adults, and show evident regard for the eggs

and very tender young, which are scattered at random through the passages, and might easily be destroyed by them in their movements. If thrown into a panic, the young larvæ scurry away with an undulating movement of their bodies, but the older larvæ will frequently stop at the nearest intersecting passageway to let the small fry pass, and show fight to cover their retreat. When full grown the larva excavates a cell, or chamber, into which it retires to undergo its transformations. The pupa cells are cut parallel with the grain of the wood and generally occur in groups of eight to twelve along some of the deeper passages. The older portions of the galleries are blackened by the long-continued formation of the food fungus. In the ambrosia of *Platypus compositus* the terminal cells are hemispherical, and are borne in clusters upon branching stems."

The habits of several genera of ambrosia beetles of the family Scolytidæ were investigated by Hubbard, and one of our species, *Xyleborus xylographus*, which has an extensive circumpolar distribution and is common in the wood of fruit-trees, has also been studied by Eichhoff (1881) and Hopkins (1898). I quote the latter's account of this insect which may serve as a paradigm of the whole group:

"The fertilized females pass the winter in their brood chambers and emerge in the spring (April and May, near Morgantown, W. Va.). They are then attracted to sickly, dying or felled trees, in the living or moist dead wood of which they prefer to excavate their brood galleries. A crevice or opening in the bark, such as may be made by other insects, or, as I have observed, those made by the yellow-bellied woodpecker, but more commonly the edge of a wound, in a dead place on a living tree, is selected as a favorite point of attack. Here a female will commence the excavation of a mine, and after she has penetrated the wood a short distance, another female (as I have observed) will come to her assistance, one working at the excavation, while the other guards the entrance and assists in expelling the borings. The primary or main gallery is usually extended into the heartwood before eggs are deposited. When the primary gallery is completed (according to Hubbard) a bed is provided on the sides of the gallery for the propagation of the special species or variety of ambrosia fungus which is to furnish food for the

future broods. The first set of eggs are few in number (five to ten) and are placed without any protection on the sides near the end of the main gallery, or in cavities or short branching galleries, one-half to one inch from the end, where upon hatching, the young larvæ find a supply of ambrosial food. After the first set of larvæ have attained considerable size, another set of eggs are deposited, and so on at intervals until a large family is reared, in which eggs, larvæ of all stages of development, pupæ, and young and old adults are found crowded promiscuously in leaf-like brood-chambers which are continually broadened or extended by the adults and possibly by the larvæ, to make room for the increase. It appears that the brood-chambers are broadened and extended by the adults, and that the borings, mixed with the fungus, are softened and furnish additional food for the larvæ and young beetles." At this point in his account Hopkins introduces the following note: "In a brood-chamber before me just cut from a nearby apple tree, I find a pupa minus an abdomen. No predaceous enemies can be found, but two or three half-grown larvæ are in such a position as to make the circumstantial evidence quite plain that they are to blame for the multilation. The remaining portion of the pupa is in a normal condition, which would indicate that the attack had been recent and when the victim was alive. This would also indicate that the helpless pupæ may furnish food for the larva in case of a scarcity of ambrosia, or that they may be thus disposed of to prevent an overcrowded brood-chamber."

The account of *Xyleborus* continues: "Mr. Hubbard records the discovery of a death chamber, or a kind of catacomb, in which the dead mother beetles and other dead friends or foes of a large colony are consigned by the survivors. In some fresh specimens of galleries before me I find the same thing, but it appears that in addition to a resting place for the dead, it is also utilized for the disposal of all objectional and refuse matter, which owing to the crowded condition of the chamber, cannot be conveniently expelled from the entrance. One of the males found in this set of chambers was excavating a burrow in the mass of material in the death or garbage chamber. Whether he was excavating his own tomb, or simply providing bachelor quarters, I cannot say. The proportion of males in this, as in

all other species of the genus *Xyleborus*, is remarkably small. There are usually not more than three males in the largest colonies, or groups of brood-chambers. It would appear from observations made by Swiner and Eichhoff in Germany, and the numerous colonies I have examined in this country that there is, on an average, about one male to twenty females. The males have no wings, therefore probably do not leave the brood-chambers, but remain with the over-wintering colony until all have emerged in the spring. They are then left to be smothered in overabundant ambrosial food, or to the tender mercies of predatory insect enemies which had previously been prevented from entering the brood-chambers by one or more female sentinels at the entrance. A few females may emerge from time to time during the summer to start new colonies, but from the excessively crowded condition of the brood-chambers during the fall and winter months, it would appear that the older adults of the broods excavate branching chambers in which new broods are developed, and that in these old and new chambers they pass the winter."

The third group of social beetles comprise the large Lamellicorns of the family Passalidæ, abundant in the tropics of both hemispheres but represented in the United States by only a single species, *Passalus cornutus* Fabr., which ranges as far north as Massachusetts and Illinois. None of our Coleopterists seem to have taken the trouble to study the habits of this common and conspicuous insect, so that it was left to Ohaus (1899-1900, 1909) to discover the social behavior in certain Brazilian species. He found that they live in rotten logs in colonies, each consisting of an adult male and female with their larvæ. The beetles excavate spacious galleries, comminuting the wood and probably treating the particles with some digestive enzyme, so that they can be eaten by the larvæ, which slowly follow along the galleries just behind their tunneling parents. Owing to the structure of their mouthparts the larvæ are quite unable to break down the wood, and when removed from their parents soon die. The beetles not only guard their greenish eggs and diligently provide food for their larvæ, but also protect the pupæ and feed the imaginal young till their chitinous integument is completely hardened. In a former paper (Wheeler and Bailey,

1920) I have published an account of the stridulatory organs of the larval and adult *Passalus* and have given reasons for believing that all the members of colony are kept together by the shrill sounds they are able to emit.

During the summer of 1920 while in Trinidad and British Guiana my son Ralph and I made a few observations on several of the species of *Passalus* which are very common in rotten logs throughout the jungle. Just under the bark the beetles make large, flat cavities, which are later very often occupied by the fungus-growing ants of the genera *Apterostigma, Myrmicocrypta* and *Cyphomyrmex,* and evidently furnish just the right places for their more or less globular gardens. In each of the *Passalus* colonies examined during July and August there were only two adult beetles, usually accompanied by a troop of larvæ varying little in size and evidently belonging to a single brood. In one log, however, we found a pair of the beetles guarding a batch of about 40 large, olive-green, broadly elliptical eggs, some of which had just hatched. The young larvæ closely resembled the older individuals in the structure of the peculiarly modified paw-like metathoracic legs, which are rubbed over the finely ridged middle coxæ during stridulation, but the hairs on the body were conspicuously longer and coarser. Our observations on the beetles and their larvæ both in the field and in the laboratory, confirm the statements of Ohaus.

The preceding account of the Platypodids, Scolytids and Passalids will suffice to show that they have reached a more advanced stage of social development than *Coccidotrophus* and *Eunausibius,* though the latter exhibit certain interesting resemblances to such ambrosia beetles as *Xyloterus.* The two Silvanids really represent a stage in social development intermediate between that of the families mentioned and the merely gregarious *Silvanus, Oryzæphilus, Nausibius* etc. Although the colonies of *Coccidotrophus* and *Eunausibius* are founded by pairs of parent beetles and in the climax stage of their development may comprise a considerable number of offspring in all stages of development, yet the latter do not seem to be the recipients of any special care on the part of the parents, unless we interpret as such the guarding of the petiolar cavity and the deepening of the food-grooves which would seem to render the nutritive parenchyma more accessible

to the larvæ. And although all the members of the colony, beetles and larvæ alike, seem to be very indifferent to one another, except when they are competing for the honey-dew of the same coccid or when larvæ occupy cocoons in process of construction by other larvæ, yet under normal conditions there are no signs of hostility on the part of the beetles and larvæ even when other individuals are very annoying. Moreover, the use of the petiolar cavity as a common domicile, with its kitchenmiddens and more or less definite arrangement of the frass-ridges and wall about the entrance, the droves of coccids and the definite orientation of the eggs and cocoons, all show a much more socialized condition than anything that has been hitherto observed in other Cucujids. I believe, therefore, that I am justified in regarding the two *Tachigalia* Silvanids as representing a fourth group of social beetles, of a more primitive type than any of the three families above considered and differing in the absence of any definite preparation of larval food by the parents. No such preparation is necessary, in fact, owing to the peculiar conditions under which the *Coccidotrophus* and *Eunausibius* live, since both the young and the adults feed on the same substances and these are furnished by the plant and the coccids, which in turn feed on the same specialized parenchyma as the beetles.

No doubt the toleration by the beetles and larvæ of such different insects as the coccids, the *Scymnus* larvæ, the larval and adult *Diadiplosis*, the *Entomobrya*, *Aphiochaeta* and probably also of the adult *Blepyrus*, is due to the same causes as the toleration by so many ants and termites of numerous myrmecophiles and termitophiles. Such guests, parasites and synoeketes can, of course, manage to live only among insects which through long association with individuals of their own species have come to tolerate or even to seek the presence of insects belonging to alien, or unrelated species.

2.—The Development of the Feeding-Habits of the Social Silvanids.

There would seem to be little doubt that the primitive food of *Coccidotrophus* and *Eunausibius* is the nutritive parenchyma of the *Tachigalia* petioles. But this is a very specialized diet

compared with that of other Silvanidæ. Although such genera as *Silvanus*, *Oryzæphilus*, *Cathartus* and *Nausibius* eat by preference vegetable substances with high protein, starch or sugar content, none of these forms is known to devour the tissue of growing plants, and it is even doubtful whether White's statement (1872) that the Cucujid *Dendrophagus crenatus* feeds on the inner bark of conifers, is correct (see Zoologica III, No. 5). The *Tachigalia* beetles are primarily attracted by the tree and there is every reason to regard this peculiar Leguminous plant as their only host, so that in this respect, also, they are highly specialized, for while some of the Silvanids, Læmophloeids and Cucujids (*sens. str.*) prefer particular trees, they seem nevertheless to thrive equally well in trees of different species, probably because they do not eat the living plant tissues but merely require special moisture conditions or the presence of certain other insects. We must suppose, furthermore, that the social Silvanids are primarily attracted to the *Tachigalia* by certain chemical substances in the petioles, a supposition which seems to offer the only satisfactory explanation, as Picard (1919) has shown, for the selection of particular host plants by particular insects. We should have to suppose also, that the beetles can discriminate between the petiolar substances of young shade—and older sun-trees, since they confine their attentions to the former. This is not surprising when we consider that some insects, e.g., certain Cynipid gall-flies exhibit even more delicate powers of discrimination since, when ovipositing, they seem to be able to distinguish between the viability of different buds or leaves on the same branch.

An even more interesting problem is presented by the coccidophily of *Coccidotrophus* and *Eunausibius*, for nothing like it has been observed in any other beetles, and apart from the ants, few insects are known to have developed the ability to solicit honey-dew from any of the Homoptera. I find only the two following cases in the literature, the first an observation by Belt in his "Naturalist in Nicaragua" (1884, p. 228), on wasps attending Membracids: "Similarly as, on the savannahs, I had observed a wasp attending the honey-glands of the bull's horn acacia along with the ants, so at Santo Domingo another wasp, belonging to quite a different genus *(Nectarinia)*, attended some

of the clusters of frog-hoppers, and for the possession of others a constant skirmishing was going on. The wasp stroked the young hoppers, and sipped up the honey when it was exuded, just like the ants. When an ant came up to a cluster of leaf-hoppers attended by a wasp, the latter would not attempt to grapple with its rival on the leaf, but would fly off and hover over the ant; then when its little foe was well exposed, it would dart at it and strike it to the ground. The action was so quick that I could not determine whether it struck with its fore-feet or its jaws, but I think it was with the feet. I often saw a wasp trying to clear a leaf from ants that were already in full possession of a cluster of leaf-hoppers. It would sometimes have to strike three or four times at an ant before it made it quit its hold and fall. At other times one ant after the other would be struck off with great celerity and ease, and I fancied that some wasps were cleverer than others. In those cases where it succeeded in clearing the leaf, it was never left long in peace. Fresh relays of ants were continually arriving, and generally tired the wasps out. It would never wait for an ant to get near it, doubtless knowing well that if its little rival once fastened on its leg, it would be a difficult matter to get rid of it again. If a wasp first obtained possession, it was able to keep it; for the first ants that came up were only pioneers, and by knocking these off, it prevented them from returning and scenting the trail to communicate the intelligence to others."

The second case is more remarkable and refers to a Gerydine Lycænid butterfly of India, described by Bingham (1907, p. 287): "A remarkable habit in one member of the subfamily, viz., *Allotinus horsfieldi*, has been communicated to me by Colonel H. J. Barrow, R. A. M. C. He writes: 'I don't know whether you have observed the habits of a small plain butterfly which I caught in Maymyo. I watched it often in the jungle, sometimes for an hour at a time. It puzzled me at first to know why it took such an immense time to settle. It would keep within one yard of a spot and almost settle, twenty times perhaps, before it actually did. Its legs are immensely long and I discovered why. It settles over a mass of Aphides and then tickles them with its proboscis, just as ants do with their antennæ and seems to feed on their exudations.' The butterfly would settle over rather large ants

that were attending the aphids 'and did not mind one or two actually standing up and examining its legs to see who was there. The ants did not attack it in any way.'"

A comparison of the behavior of the insects considered in the foregoing paragraphs is very instructive. The predilection of ants for various Homoptera (aphids, coccids, membracids, cercopids and psyllids) is well known. Though never observed among the predatory Dorylinæ and Cerapachyinæ and rare among the Ponerinæ and Pseudomyrminæ this predilection is, nevertheless, so prevalent among the higher subfamilies (Myrmicinæ, Dolichoderinæ and Formicinæ) that it has not escaped the most casual observer. When this type of behavior is highly developed, as in our species of *Lasius*, the ants display not only an exquisite deftness in stroking their trophobionts but also a decidedly proprietary interest in them, most clearly evinced by building peculiar carton or earthen shelters over them, aggressively defending them from their foes, or even collecting them and their eggs in the nests, distributing them over the surfaces of suitable plants and conveying them to places of safety when the colonies are disturbed. The whole performance is so elaborately adaptive as to suggest on the part of the ants an intimate acquaintance with the requirements and habits of their wards. This is also indicated when the latter fail to respond to stroking, for the ants do not wear themselves out by prolonged solicitation after their cattle have discharged their honey-dew, but stand around as if waiting for more of the saccharine liquid to accumulate.

The wasp described by Belt and the butterfly described by Bingham are really robbers, the former having learned to dispossess the ants of their wards, at least temporarily, the latter to overreach the ants and obtain the honey-dew by stealth. Though very different, the relations of the beetles to their coccids are no less extraordinary. The case is, indeed, so far as known, unique among the Coleoptera. Unlike many species of ants, the beetles have not yet learned to pick up the coccids and carry them about, but merely accept them as an integral part of the normal environment or as members of the colony. The fact that the beetles clearly recognize the signal of the prospective emission of the honey-dew by the coccids, when they raise their caudal segments,

and the fact that they devote more attention to the posterior than to the anterior end of the larger coccids, implies a delicate discrimination, because both ends of the coccid's body are so very much alike. Furthermore, the beetle's antennæ and mouthparts seem to be so clearly adapted to dealing with the coccids as to indicate that the trophobiotic relations between the two species have been in existence for a very long time. The beetle's extraordinary perseverence in stroking individual coccids after they have been exhausted by repeated emissions of honey-dew might be interpreted either as a very thorough and hence highly adaptive method of exploiting the coccids, or as due to a very imperfect discernment of their physiological peculiarities.

Obviously the most remarkable item of behavior in *Coccidotrophus* and *Eunausibius* is the stroking of the coccids by the larvæ of all stages, as well as by the adult beetles. No one has even considered the possibility of a similar performance by the larvæ of ants, wasps or butterflies, since it is difficult to imagine creatures more unfitted for such behavior. Nevertheless, Mr. W. F. Fiske informs me that while he was investigating certain injurious insects in British East Africa, he saw small worker ants climbing a tree with their larvæ and holding them to the posterior ends of aphids, so that they could feed on the honey-dew voided in response to the antennal solicitations of their nurses! Unfortunately no specimens of the ants were preserved, and from Mr. Fiske's description I am unable to determine even the subfamily to which they belonged, but I have no reason to doubt the statement of an entomologist so competent and so keenly observant. I surmise that the ant must have been some Myrmicine which is unable to feed its larvæ by regurgitation, as otherwise such behavior would be superfluous.

So specialized a habit as the coccidophily of the two genera of social Silvanids calls for some consideration of its possible phylogenetic origin. Under existing conditions, the beetles either find the coccids already established in petioles that have been previously inhabited by other beetle colonies or by other insects, or the coccids enter the young petioles just after they have been perforated by the beetles, for insects with sucking mouthparts cannot, of course, gain access to the cavities in any other way. That they migrate into the petioles as very young individuals is

certain. Later, after completing their growth, they are often too bulky to escape through the entrances made by the beetles, and as such imprisoned coccids contain eggs, they might be supposed to breed in the petioles. I have never been able to find either the males or the deposited eggs in the petioles, and as the total number of coccids in a petiole is too small to indicate the survival of many of the young, I suspect that the beetles, though averse to devouring the young or mature coccids, nevertheless consume many of the eggs. How the coccids manage in the first place to reach the individual *Tachigalia* plant is a problem which presents itself also in the case of any of the other often widely distributed species of the family. That ants have much to do with carrying certain species of coccids to their host-plants is very probable. The only other active agents in such distribution would seem to be birds or the wind.

Soon after they enter the petioles the coccids seek out the strands of nutritive parenchyma, and sink their slender beaks into the tissue. And as the beetles keep gnawing at the same strands, grooves or narrow depressions are soon made in which the coccids settle, one behind the other, in rows, with the long axes of their bodies parallel with the long axis of the petiole. Thus the coccids naturally and inevitably come to lie in the paths of the feeding beetles, so that these can hardly avoid continual contact with the waxy creatures and their excrement. Probably at first the coccids simply voided their excrement in the grooves, thus drenching the surface of the nutritive parenchyma, so that the beetles found their bread spread with syrup. But this could hardly be an unalloyed blessing, because a sticky liquid spread on the walls of the petiole would almost certainly be injurious or fatal to the eggs, pupæ and younger larvæ of the beetles. We may therefore conjecture that the latter soon learned to stroke the coccids and to swallow the honey-dew at its very source, and that they have even acquired so keen an appetite for the liquid that it has now become a very important if not an essential constituent of their diet. The exploitation of such a constant and energizing supply of syrup, moreover, would surely tend not only to lengthen the original life-span of the adult beetles but also to increase the number of their progeny and hence the size and vigor of their colonies. This is suggested by the conditions

in certain ants, *e. g.*, our yellow, hypogæic species of *Lasius*, which are able to develop populous colonies mainly, if not exclusively, on a diet of honey-dew derived from root-aphids and root-coccids.

Inasmuch as the larvæ, from their very youngest stages, no less than the adult beetles, continually stroke the coccids, the question arises as to whether the habit was first acquired by the larvæ, or by the beetles, or whether both instars developed it simultaneously. An answer to this question might, perhaps, be forthcoming if we could determine whether the larva or the adult beetle shows the greater structural adaptation of the antennæ and mouthparts to dealing with the coccids. The larvæ as I have shown, use both their antennæ and maxillæ in the process, the adults only the antennæ, but although the beetles are able to cover a greater area of the coccid's surface with their antennal clubs, the larger larvæ at least, by combining both pairs of organs, can probably produce a stimulus no less intense and effective. The larvæ are certainly more alert, restless and inquisitive than the beetles and the mandibles in the youngest stages seem to be very poorly adapted to feeding on the nutritive parenchyma. It is therefore quite as probable that the habit of stroking the coccids was first acquired by the young larvæ and later continued in the adult as that it originally appeared in the latter and was inherited in earlier and earlier ontogenetic stages till it came to be manifested by the just-hatched larva less than a millimeter in length. As shown by the observations recorded on p. 70 such larvæ show an even greater avidity for the honey-dew than the adult beetles. Since the stroking of the female beetle by the male during the courtship is precisely like the stroking of the coccids, we might be tempted to conjecture that the habit had arisen first in the adult as a modification of the sexual appetite, but this is, perhaps, rather far-fetched.

3.—The Building of the Cocoon.

The few data I have been able to gather concerning the processes accompanying pupation in the beetles allied to *Coccidotrophus* and *Eunausibius* are reproduced in Zoologica III, No. 5. The pupating larvae of some Læmophloeids, Silvanids and Cucu-

jids are described as attaching themselves by the last segment to the substratum, and pushing back the larval skin to the tip of the abdomen which remains fixed to the exuvium. In *Oryzæphilus surinamensis* the larva before pupating makes a rude cocoon by agglutinating particles of food or detritus with an oral secretion, but I have seen no circumstantial account of the process which may be of considerable interest in connection with the cocoon-building of *Coccidotrophus.* The *Cucujus* larva also makes a rude cocoon (see p. 177).

The construction of a substantial cocoon by the larvæ of the social Silvanids would seem to be necessary, because a nude pupa, even if attached to the petiolar wall by its anal end, would be exposed to injury by the numerous beetles and larvæ moving about in the narrow cavity: But the way in which the cocoon is constructed is, to say the least, very unusual. So far as known, the larvæ of Coleoptera and other insects, when engaged in making such structures, remain *in situ* and build the cocoon as an envelope around the body, using for the purpose extraneous particles of earth, detritus, wood or frass, or threads of silk spun from the sericteries or more rarely a secretion of the Malpighian tubules, as in ant-lions and certain weevils, as described by Knab (1915a, 1915b) and others, or several secretions as described by Böving for *Donacia* (1910). The *Coccidotrophus* larva, however, laboriously collects minute particles of living plant-tissue, mixes them with saliva and builds them up in a very definite manner, repeatedly leaving the structure to go afield for the purpose of collecting the necessary materials. When the cocoon is all but completed the larva enters, and becoming a voluntary prisoner, closes the aperture at the end with materials scraped from the inner surfaces of the walls. I have failed to find in the entomological literature any account of such a method of cocoon-building, which in many particulars resembles the nest-building of certain birds and rodents.

The only suggestion I can make in regard to the possible origin of this behavior is that it may be derived in some way from the beetle's habit of building up its frass in more or less regular ridges, or welts between the food-grooves or immediately around the entrances to the petioles. I have been unable actually

to witness this performance as the beetles never exhibited it after the petioles were cut open. I am inclined to believe that the feces are not simply voided in the spaces between the food-grooves but actually built up with the aid of the mouthparts. This seems to be clearly indicated by the circular wall around the entrances (Fig. 11). Perhaps the larvæ have quite as much to do with the construction of the ridges as the beetles.

4.—Concluding Remarks On the Behavior of the Social Silvanids

All modern observers of insects have been deeply impressed by the highly mechanized character of their behavior, but it is equally true that those who have most closely studied these organisms both under natural and experimental conditions have failed to find that the behavior of any one of them can be completely reduced to a rigid system of automatic or stereotyped reactions. While the behavior of certain forms such as the larval ant-lion, according to Doflein (1916) or the larval worm-lion *(Vermileo)*, as shown by my unpublished studies, seems to consist almost entirely of a small number of reflexes, the behavior of other insects, such as the solitary wasps, termites and social Hymenoptera, often exhibits considerable plasticity, modifiability or adaptability. Between these extremes we find the majority of insects with a certain modicum of the latter type of behavior. To this group we may assign the social Silvanids. The interpretation of their various activities necessarily involves some reference to the behavior of insects in general and the assumption of a definite attitude towards certain intricate and much discussed questions. The limitations of space compel me, therefore, either to leave the whole matter unconsidered or to treat it in a very brief and sketchy manner. I prefer to adopt the latter course.

The fashion which required one to explain as much as possible of the behavior of an insect in terms of tropisms, or taxes, and measured the value of one's work by the success achieved in the endeavor, seems to be rapidly passing. Thirty years ago I followed the fashion with some enthusiasm, but continued observation of the ways of insects has made me very

dubious in regard to the whole subject of the tropisms. My present position concerning them is not essentially different from that of Jennings (1904, 1906, 1909), von Buddenbrock (1915), Claparède (1912, 1913), and others. I should, therefore, interpret them as adaptive, secondarily developed reflexes and not as unique, primitive elements in the genesis of instinctive behavior.

There are, nevertheless, in the behavior of *Coccidotrophus* certain phenomena, which some might be inclined to interpret as tropisms, especially the reactions to contact, light and chemical stimuli. The reader who has followed my account of the beetle will have noticed the peculiar orientation of some of its stages and of some of the associated insects with respect to the walls of the long fusiform petiolar cavity which they inhabit. Thus the eggs, cocoons and pupæ of the beetle are always placed with their long axes parallel with the long axis of the petiole, and the coccids, while feeding, the cocoons of *Blepyrus*, which are formed within the bodies of the coccids, and the nude pupæ of *Scymnus* assume the same orientation. The food grooves which are excavated by the beetles and the frass-ridges which they build, as well as the longer axis of the entrance are all longitudinal. Moreover, the beetles spend much time lying in the food-grooves with their narrow bodies longitudinally oriented and with as much as possible of their surface in contact with the floor and walls of the grooves.

At first sight this striking series of orientations would seem to be best described as tropistic, perhaps as due to some form of thigmotropism, but it is evident that the only behavior which might be legitimately regarded as such is that of the adult beetle when resting or moving in the food grooves. The Collembolans and the larvæ of *Scymnus* and *Diadiplosis* exhibit not the slightest tendency to assume a similar orientation, and the *Coccidotrophus* larvæ show no traces of it till they start their cocoons. Even then, though they orient their cocoons, they assume a position with their long axes parallel with the long axis of the petiole only while actually adding particles to the walls and after they have pupated. It is evident, furthermore, that nearly all the orientations mentioned can be traced more or less directly to peculiarities in the structure of the petiole, i.e., to the shape of

its cavity and the histological structure of its walls, and especially to the singular arrangement of the nutritive parenchyma in long, narrow strands. The beetles gnaw these out and thus form grooves, which in turn orient the coccids and their internal parasites. The orientation of the frass ridges and beetle cocoons is also determined by the grooves, and the position of the *Coccidotrophus* eggs is very probably due to their being laid and attached by the beetles while they are lying in the depressions between the frass ridges. Thus the various orientations are merely so many direct or indirect adaptations to the nutritive parenchyma and the long narrow petiolar cavity. The latter clearly determines to some extent the longitudinal arrangement of the bulky cocoons, just as a long Pullman car makes it advisable for us to arrange the berths in a similar manner.

One orientation, that of the entrance, is not so easily explained. In all the petioles I have examined, the long axis of the entrance is parallel with the long axis of the petiole. It is evident that it precisely fits the head of the beetle and that the latter while gnawing it must stand on the outer surface of the petiole at right angles to its long axis. When the surface is longitudinally grooved, as is sometimes the case, the entrance can, of course, have no other orientation, but often the surface is quite smooth and it is difficult to see why it should be easier for the insect to gnaw through the tissue lengthwise rather than crosswise of the grain. It is also evident that while guarding the entrance the beetle has its long axis at right angles to the long axis of the petiole, but since a tubular wall is built around the inside of the orifice (Fig.11) the insect's reaction might be regarded as thigmotropic, like its reactions to the walls of the food grooves.

Nevertheless, I am convinced that the responses of the adult beetle to contact stimuli may be more properly interpreted as typical and highly adaptive reflexes. This is clearly indicated by the structure of the insect. The long, parallel-sided, subcylindrical form of the body and the shortness of the legs are merely so many adaptations to living in narrow tubular cavities. The same type of structure reappears as an independent development in each of many different families of beetles, which live in cylindrical cavities or burrows, e.g., the Scolytidæ, Platypodi-

dæ, Brenthidæ, Bostrychidæ, Buprestidæ *(Agrilus)*, Cleridæ, Trogositidæ, Histeridæ *(Teretrichus)*, Colydiidæ *(Colydium)*, Lyctidæ, Lucanidæ *(Ceruchus)*, Elateridæ, Parandridæ, many Cerambycidæ, Lymexylondidæ, etc. This type of body and one more extremely flattened and adapted for living under bark *(Cucujus, Brontes)*, are very common among the Cucujidæ *sens. lat.* The peculiar conformation of the front and of the mandibles of *Coccidotrophus* and *Eunausibius*, so strikingly like that of many ants *(Cryptocerus, Cataulacus, Colobopsis*, etc.) is, moreover, a definite adaptation to guarding elliptical or circular entrances to solid-walled nesting cavities. It is interesting to note also that the general shape of the body of *Coccidotrophus* and *Eunausibius* reappears in several genera of ants which regularly live in narrow plant cavities, e.g., *Colobopsis. Simopone, Cylindromyrmex, Metapone, Pachysima, Tetraponera and Pseudomyrma* (see Plate III, figs. 1 and 2). Even the larvæ and pupæ of these ants have assumed a similar form. (See Wheeler, 1918, and Wheeler and Bailey, 1920). We may say, therefore, that the whole general bodily structure of the various insects I have mentioned has been adaptively modified during their phylogenetic history and that such a modification can hardly be anything but an expression of a concomitant adaptation of their nervous system and reflexes.

Equally unsatisfactory from an ethological point of view is the reference of other behavioristic peculiarities of the social Silvanids to simple tropisms. Let us take as an example the attraction to the *Tachigalia*. I agree with Picard (1919) in his contention that phytophagous insects are attracted to their respective host-plants by particular chemical substances in the latter. Entomologists have always believed this but have usually described the phenomena as due to "odor" or "taste." To designate them as chemotropism really adds nothing to our knowledge but a technical term. The ethological question remains: Why is a particular insect species or sex attracted to a particular part of a particular species of host plant, or, in the case of the social Silvanids, why do they fly to and bore into the swellings of the petioles of young individuals of a certain species of *Tachigalia?* Undoubtedly the exquisite sense-organs in their antennal clubs enable the beetles to detect certain very delicate effluviæ emanat-

ing from the young *Tachigalia* as a whole or perhaps even from the nutritive parenchyma in its petioles, but the attraction of these odors is probably due to their having acquired a "meaning" for the beetles, because the latter throughout their larval and early imaginal stages fed on these very substances, and had, in fact, long been familiar with the petiolar cavities, the coccids, etc. The latter part of this statement also applies to the young queens of the obligate *Tachigalia* ants of the genera *Pseudomyrma* and *Azteca* and would account for the rather unusual attachment of these insects to a definite host-tree. Hence in these cases organic memory, or "mneme," or even individual memory yields a more satisfactory explanation of the phenomena than a naked tropism.

A consideration of the responses to light leads to similar results. The beetle colonies, as we have seen are "photophobic," or live in the dark, and when the petioles are opened in the light the insects are at first much agitated but soon settle down and continue the regular routine of their existence even when the pieces of petiole are kept exposed to artificial or diffuse day-light in the laboratory. The adult beetles have well-developed eyes and the larvæ have three pairs of small simple eyes on each side of the head. (Plate VII, fig. 2, Plate VIII, fig. 10). And since a certain amount of light enters the petiole through the entrance, at least when it happens to be unguarded, it is probable that under ordinary conditions the eyes are mainly useful in enabling the insects and particularly the larvæ, to stay in the dark. There is nothing to show that the young beetles, which leave the petioles to establish new colonies, do so because they become positively phototropic. The emigration may, perhaps, take place at night and even if it occurs during the day the light in the parts of the jungle where the young Tachigalias are growing, is very subdued. I believe that the young beetles must emigrate either because the space in the petiole has become too greatly reduced by the growth of the colony or because the food-supply has for the same reason become insufficient. In either case emigration would be due to internal stimuli ("physiological states"). These may also be important factors in the swarming of ants, bees and termites. We might, perhaps, even suppose that the guarding of the entrance by the beetles is due to an abortive or inhibited emigration impulse due to feebler or vaguer internal stimuli

comparable with those which sometimes impel a person who has been sitting for hours in a dimly-lighted room, to stand at the window or open door or to step out into the sunlight.

Thus while it is easy to interpret many of the activities of the social Silvanids as adaptive reflexes it is difficult to assign to such stimuli as light, contact, chemicals, etc., the leading rôle which they have in the theories of Loeb and Bohn. Much of the behavior of the beetles, such as their treatment of the coccids, the building of the cocoon, mating, the guarding of the entrance, etc., so obviously depends on internal or physiological states that, in so far it has not become completely mechanized, we may more properly regard it as made up of cyclical activities like those recognized by Herrick (1910), Craig (1918) and others in birds. Craig especially has shown how much of the behavior of birds can be interpreted as cycles of appetence, or appetite and aversion, which he defines as follows: "An appetite (or appetence, if this term may be used with purely behavioristic meaning), so far as externally observable, is a state of agitation which continues so long as a certain stimulus, which may be called the appeted stimulus, is absent. When the appeted stimulus is at length received it stimulates a consummatory reaction, after which the appetitive behavior ceases and is succeeded by a state of relative rest. An aversion is a state of agitation which continues so long as a certain stimulus, referred to as the disturbing stimulus, is present; but which ceases, being replaced by a state of relative rest, when that stimulus has ceased to act on the sense-organs."

Rignano (1920) gives this same conception a more general physiological formulation in the following passage: "Every organism is a physiological system in a stationary condition and tends to preserve this condition or to restore it as soon as it is disturbed by any variation occurring within or without the organism. This property constitutes the foundation and essence of all "needs," of all "desires," of all the most important organic "appetites." All movements of approach or withdrawal, of attack or flight, of taking or rejecting which animals make are only so many direct or indirect consequences of this perfectly general tendency of every stationary physiological condition to remain constant. We shall soon see that this tendency in its

turn is only the direct result of the mnemic faculty characteristic of all living matter. This single physiological tendency of a general kind, accordingly, is sufficient to give rise to a large number of the most diversified particular affective tendencies. Thus every cause of disturbance will produce a corresponding tendency to repulsion with special characteristics determined by the kind of disturbance, by its strength, and by the measures capable of avoiding the disturbing elements; and for every incidental means of preserving or restoring the normal physiological condition, there will be a quite definite corresponding tendency such as "longing," "desire," "attraction" and so forth. Even the instinct of self-preservation—when understood in the usual narrow sense of "preservation of one's own life"—is only a particular derivative and direct consequence of this very general tendency to preserve physiological invariability." This tendency, however, as Rignano remarks, is supplemented by another, "for as soon as the previous stationary condition cannot be restored by any means, that is by any movements or change ot location, the organism disposes itself in a new stationary condition consistent with its new external and internal environment. In this way there originate a large number of new phenomena called 'adaptations'."

Of course, the contention that the appetites are fundamentally important in animal behavior is not new. It is merely astonishing that they have been so consistently ignored by many modern observers. The rôle of appetency, or appetite, was set forth with great acumen by the philosopher Fouillée, especially in the third book of his "Evolutionnisme des Idées Forces" (1920, first edition 1890). The germ of the conception, however, can be traced back to Reimarus (1798) and Leibnitz (Dwelshavers, 1908, p. 181), to the "appetitus sensitivus" of the schoolmen (see Maher, 1903, Chap. 10), and the ὄρεξις and τὸ ὀρεκτικόν of Aristotle (De Anim. 3, 10; Eth. Nic. 1, 13, 18). Recently the behavioristic psychologists, psychopathologists and students of the sympathetic nervous system and internal secretions, Mosso (1899), Drever (1917), Smith and Guthrie (1921), Goddard (1919), Kempf (1918), Crile (1915), Cannon (1915), and others, have emphasized the importance of the appetites and others have stressed their peculiarities in such terms as "tumescence" and

"detumescence" in sexual psychology and "enhancement," "relief" and "catharsis" in art. Kempf (1921) in his valuable contribution to psychoanalysis has used the term "craving" instead of appetite, avoiding the "libido" of the Freudians which embodies the same notion. In a recent volume[1] Bertrand Russell takes essentially the same view of the phenomena of appetite but uses the word "desire." Most of the authors cited deal, of course, with man, but one can hardly overestimate the value of their work for the animal behaviorist and entomologist. It is certain that insects have well-developed sympathetic and glandular systems and that their alimentary and sexual behavior presents quite as definite a picture of appetites as does the corresponding behavior of the higher animals.

Fouillée believes that every appetition involves a rudimentary cognition and that automatic behavior like that of the habits and reflexes is merely lapsed appetition. If it could be shown that the latter really can have this derivation and that such ontogenetic mechanisms as habits can acquire representation in the germ-plasm and hereditary transmission, we might be in a position to give a consistent account of all animal behavior, and one which would lead us to regard the reflexes and the tropisms as ultimate, highly specialized end-stages instead of primitive, elemental components of behavior.

[1] "The Analysis of Mind," London and New York, Allen, Unwin & Macmillan, 1921.

POSTSCRIPT.

Just as the final proof of this paper was being returned to the printer Prof. I. W. Bailey received a letter from Col. David Prain, Director of the Royal Botanical Gardens of Kew, with the identification of the Tachigalia. It proves to be *T. paniculata* Aublet. Col. Prain compared our specimens with Aublet's type in the British Museum Herbarium.

Among the various social beetles considered in the latter part of my paper I should have included *Phrenapates bennetti* Kirby, the habits of which were studied by Ohaus (1909) in Ecuador. I shall have occasion to return to this insect in a future publication.

BIBLIOGRAPHY

AUBLET.

1775. Histoire des Plantes de la Guiane Françoise. 4 vol., 1775. London and Paris, Didot.

BELT, T.

1888. The Naturalist in Nicaragua. 2d Ed. London, Bumpus, 1888.

BINGHAM, C. T.

1907. The Fauna of British India, including Ceylon and Burma. Butterflies. Vol. II, 1907, London, Taylor and Francis.

BLATCHLEY, W. S.

1910. An Illustrated Descriptive Catalogue of the Coleoptera or Beetles (Exclusive of the Rhynchophora) Known to Occur in Indiana. Indianapolis, Nature Publ. Co., 1910.

BLISSON, J. F. J.

1849. Description de la Larve et de la Nymphe du Silvanus sexdentatus Fabr. Ann. Soc. Ent. France (2) 7, 1849, pp. 163-172, pl. 6, figs. 1-18.

BODINE, J. H.

1920. Factors Influencing the Water Content and the Rate of Metabolism of Certain Orthoptera. Journ. Exper. Zool. 32, 1921, pp. 137-164, 6 figs., 6 tables.

BÖVING, A.

1910. Natural History of the Larvæ of Donaciinæ. Internat. Rev. gesamt. Hydrobiol. Hydrograph. 3, 1910, pp. 45-108. Biol. Suppl., pp. 1-4, 7 pls. and 70 textfigs.

VON BUDDENBROCK, W.

1915. Die Tropismentheorie von Jacques Loeb. Biol. Centralbl. 36, 1915, pp. 481-506. Trans. in Journ. Anim. Behav. 6, 1916, pp. 341-366.

CANNON, W. B.

1915. Bodily Changes in Pain, Hunger, Fear and Rage. N. Y. and London, D. Appleton & Co., 1915.

CASEY, T. L.

1884. Revision of the Cucujidæ of America North of Mexico. Trans. Amer. Ent. Soc. 11, 1884, pp. 69-112, 5 pls.

CHAMPION, G. C.

1896b. Silvanus surinamensis (Linn.) Ent. Month Mag. (2) 7, 1896, pp. 268, 269.

CHITTENDEN, F. H.

1895. The More Important Insects Injurious to Stored Grain. Yearbook U. S. Dep. Agric. (1894) 1895, pp. 377-394. 9 figs.

1896. A New Grain Beetle. Canad. Ent. 28, 1896, pp., 197, 198.

1897a. Some Insects Injurious to Stored Grain. Farmers' Bull. No. 45. U. S. Dep. Agric., 1897, pp. 1-24, 18 figs.

1897b. Some Little-known Insects Affecting Stored Vegetable Products. Bull. No. 8 (N. S.) U. S. Dep. Agric. Div. Ent., 1897, pp. 1-45, 10 figs.

1911. A List of Insects Affecting Stored Products. Bull. No. 96, Pt. 1, U. S. Dep. Agric. Bur. Ent., 1911, pp. 1-7.

CLAPARÈDE, E.

1912. Point de Vue Physico-Chimique et Point de Vue Psychologique. Scientia 11, 1912, pp. 251-258.

1913. Article "Thierpsychologie" in "Handwörterbuch der Naturwissenchaften". Bd. 9, Jena, Gustav Fischer, 1913.

COMSTOCK, J. H.

1882. Note on the Structure of Mealy Bugs. Rep. U. S. Dep. Agric. (1881), 1882, p. 214.

COQUEREL, C.

1849. Note sur les Métamorphoses du *Silvanus sexdentatus*. Ann Soc. Ent. France (2) 7, 1849, p. 172.

CRAIG, W.

1918. Appetites and Aversions as Constituents of Instincts Biol. Bull. 34, 1918, pp. 91-107.

CRAIGHEAD, F. C.

1920. Biology of Some Coleoptera of the Families Colydiidæ and Bothrioderidæ. Proc. Ent. Soc. Wash. 22, 1920, pp. 1-13, 2 pls., 1 textfig.

CRILE, G. W.

1915. The Origin and Nature of the Emotions. Phila. and London, W. B. Saunders Co., 1915.

DIMMOCK, Mrs. A. K.

1885. The Insects of Betula in North America. Psyche, 1885, pp. 239-243, 271-286.

DIMMOCK, G.

1884. Article "Beetles" in Standard Natural History. Vol. 2, 1884. Boston, S. C. Cassino & Co.

DOFLEIN, F.

1916. Der Ameisenlowe, eine biologische, tierpsychologische und reflexbiologische Untersuchung. Jena. Gustav Fischer, 1916, 138 pp., 43 figs., 10 pls.

DORAN, E. W.

1892. The Evolution of Heat by *Silvanus cassiæ*. Proc. Ent. Soc. Wash. 2, 1892, pp. 325-327.

DREVER, J.

1917. Instinct in Man, a Contribution to the Psychology of Education. Cambridge, Univ. Press, 1917.

DWELSHAUVERS, G.

1908. La Synthèse Mentale. Paris, F. Alcan, 1908.

EICHOFF, W.

1881. Die Europäischen Borkenkäfer. Berlin, J. Springer, 1881, pp. 280-281.

EMERY, C.

1893. Studio Monografico sul Genere Azteca Forel. Mem. R. Accad. Sc. Ist. Bologna (5) 3, 1893, pp. 319-352, 2 pls.

ESCHERICH, K.

1902. Biologische Studien über algerische Myrmekophilen, zugleich mit allgemeinen Bemerkungen über die Entwicklung und Bedeutung der Symphilie. Biol. Centralbl. 22, 1902, pp. 638-663, 4 figs.

FELT, E. P.

1911a. A Generic Synopsis of the Itonidæ. Journ. N. Y. Ent. Soc. 19, 1911, pp. 31-62.

1911b. Habits and Galls of American Gall Midges. Journ. Econ. Ent. 4, 1911, pp. 451-484.

FISKE, W. F.

1905. Catogenus rufus. A Coleopterous Parasite. Proc. Ent. Soc. Wash. 7, 1905, pp. 90-92.

FORBES, S. A.

1880. Studies of the Food of Birds, Insects and Fishes Made at the Illinois State Laboratory of Natural History at Normal, Illinois. Bull. Ill. State Lab. Nat. Hist. 1, 1880 (second ed. 1903), 176 pp.

1884. Insects Injurious to the Strawberry. Rep. State Ent. Illinois 13, 1884, pp. 60-180.

1894—1905. A Monograph of the Insect Injuries to Indian Corn. Part I, 18th Rep. State Ent. Illinois, 1894, 171 pp., 15 pls. Part II, *ibid.* 23rd Rep. 1905, 273 pp.

1915. The Ecological Foundations of Applied Entomology. Ann. Ent. Soc. Amer. 8, 1915, pp. 1-19.

FOREL, A.

1904. In und mit Pflanzen lebende Ameisen aus dem Amazonas-Gebiet und aus Peru. Zool. Jahrb. Abth. Syst. 20, 1904, pp. 677-707.

1906. Fourmis Néotropiques Nouvelles ou peu Connues. Ann. Soc. Ent. Belg. 50, 1906, pp. 225-249.

1912. Formicides Néotropiques. Part IV. Mém. Soc. Ent. Belg. 20, 1912, pp. 1-32.

FOUILLÉE, A.

1920. L'Évolutionnisme des Idées-Forces. 6th Ed. Paris. F. Alcan, 1920 (First ed. 1890).

FOWLER, C.

1889. The Coleoptera of the British Islands Vol. III. Clavicornia London, L. Reeve & Co., 1889.

GANGLBAUR, L.

1899. Die Käfer von Mitteleuropa. Bd. 3. Vienna, C. Gerold's Sohn, 1899.

GAVIT, J. E.

1849. Corn or Grain Weevil of Europe *(Calandra granaria)* and *Silvanus surinamensis*, the Weevil most Common in America. Trans. N. Y. State. Agric. Soc. for 1848. Vol. 8, 1849, pp. 656-662, plate.

GIRAULT, A. A.

1912. Insects Injurious to Stored Grains and their Ground Products. Bull. No. 156, Univ. Illinois Agric. Exper. Station, 1912, pp. 67-92, 12 figs.

GLOVER, T.

1869. The Food and Habits of Beetles. Rep. U. S. Com. Agric. 1868 (1869), pp. 78-117, 189 figs.

GODDARD, H. H.

1919. Psychology of the Normal and Subnormal. New York, Dodd, Mead & Co., 1919.

GROUVELLE, A.

1896. Nitidulides, Colydiides, Cucujides et Parnides récoltés par M. E. Grouvelle au Brésil et autres Clavicornes nouveaux d'Amérique. Ann. Soc. Ent. France 65, 1896, pp. 177-216, 26 figures.

1913. Notes sur les Silvanini (Col. Cucujidæ). Ann. Soc. Ent. France 81, 1913, pp. 313-386.

GUILLEBEAU, F.

1890. Note sur les Silvanus. Rev. d'Ent. 9, 1890, pp. 220-224.

HAGEDORN, M.

1907. Pilzzüchtende Borkenkäfer. Naturw. Wochenschr. N. F. 6, 1907, pp. 289-293, 12 figs.

1910. Coleoptera. Fam. Ipidæ. Wytsman's Genera Insectorum, 1910, pp. 1-178, 14 pls.

HAMILTON, J.

1886. Natural History Notes on Certain Coleoptera. Canad. Ent. 18, 1886, pp. 26-30.

HANDLIRSCH, A.

1908. Die Fossilen Insekten und die Phylogenie der Rezenten Formen. Text and Atlas. Leipzig, Wilh. Engelmann, 1908.

HARMS, H.

1906. Leguminosæ in II Beiträge zur Flora der Hylæa nach den Sammlungen von Ule's Amazonas-Expedition. Verh. bot. Ver. Prov. Brandenburg 48, 1906, p. 164.

HEIN, S. A. A.

1920. Technical Experiences in the Breeding of *Tenebrio molitor*. K. Akad. Vetens. Amsterdam. Proc. 23, 1920, pp. 193-218

HERRICK, T. H.

1910. Instinct and Intelligence in Birds. Pop. Sci. Month., 1910, pp. 532-556, 82-97, 122-141.

HOPKINS, A. D.

1898. On the History and Habits of the Wood Engraver Ambrosia Beetle *Xyleborus xylographus* (Say), *Xyleborus saxeseni* (Ratz), with Brief Descriptions of Different Stages. Canad. Ent. 30, 1898, pp. 21-29, 2 pls.

HOWARD, L. O. and C. L. MARLATT.

1896. The Principal Household Insects of the United States, with a Chapter on Insects Affecting Dry Vegetable Foods by F. H. Chittenden. Bull. No. 4, N. S., U. S. Dep. Agric. Div. Ent. 1896, 130 pp., 63 figs.

HUBBARD, H. G.

1897. The Ambrosia Beetles of the United States. Bull. 7 (N. S.) Div. Ent. U. S. Dep. Agric. 1897, pp. 9-30, 34 figs.

1906. Ambrosia Beetles. Yearbook, U. S. Dep. Agric. 1906, pp. 421-430, 7 figs.

HUBER, J.

1908. Materiales para a Flora Amazonica. VII. Plantæ Duckeanæ austro-guyanenses. Bol. Mus. Goeldi 5, 1908, pp. 387, 388.

JENNINGS, H. S.
1904. Contributions to the Study of the Behavior of Lower Organisms. Carnegie Inst. Wash. Publ. No. 16, 1904.
1906. Behavior of the Lower Organisms. New York, Columbia Univ. Press, 1906.
1909. Tropisms. C. R. 6me. Congrès. Internat. Psychologie Geneva, 1909, pp. 307-324.

KALTENBACH, J. H.
1874. Die Pflanzenfeinde aus der Klasse der Insekten. Stuttgart, Julius Hoffmann, 1874.

KEMPF, E.
1918. The Autonomic Functions and the Personality. Nervous and Mental Disease Monogr. Series No. 28. N. Y. and Washington, 1918.

KEMPF, E. J.
1920. Psychopathology. St. Louis, C. V. Mosby Co., 1920.

KIEFFER, J. J.
1920. Déscription de quelques Cécidomyides Nouvelles. Marcellia 1, 1902, p. 115.

KNAB, F.
1915a. The Secretions Employed by Rhynchophorous Larvæ in Cocoon-making. Proc. Ent. Soc. Wash. 17, 1915, pp. 154-158.
1915b. Dung-bearing Weevil-Larvæ. Proc. Ent. Soc. Wash. 17, 1915, pp. 193-194.

KOLBE, H.
1911. Die Vergleichende Morphologie und Systematik der Coleopteren. Mem. 1me. Congr. Internat. d'Ent. Bruxelles, 1910. Vol. 2, 1911, pp. 41-68.

KÜSTER, E.
1911. Die Gallen der Pflanzen. Leipzig, L. Hirzel, 1911.

LEA, A. M.
1904. Descriptions of New Species of Australian Coleoptera. Proc. Linn. Soc. N. S. W. 29, 1904, pp. 60-107, 1 pl.

LEBARON, W.
1874. Fourth Annual Report of the Noxious and Beneficial Insects of the State of Illinois. Springfield, 1874, pp. 18-199. 94 figs.

LECONTE, J. L. AND HORN, G. H.
1883. Classification of the Coleoptera of North America. Smiths. Misc. Coll. 507, 1883, pp. XXVIII, 567.

LENG, C. W.
1920. Catalogue of the Coleoptera of America North of Mexico. Mt. Vernon, N. Y., J. D. Sherman, 1920.

LUGGER, O.
1899. Coleoptera, or Beetles. Fifth Ann. Rep. Ent. Minnesota, 1899, 248 pp.

MACGILLIVRAY, A. D.
1921. The Coccidæ. Urbana, Ill., Scarab Co., 1921.

MAHER, M. (S. J.).
1903. Psychology, Empirical and Rational. London, Longmans, Green & Co., 1903.

MÖBIUS, K.
1877. Die Auster und die Austernwirthschaft. Berlin, 1877. Transl. "The Oyster and Oyster Culture." Rep. U. S. Fish Comm. (1880), Part VIII, 1883, pp. 683-751.

MOSSO, A.
1899. The Mechanism of the Emotions. Clark Univ. Decen. Cel. Vol., 1899, pp. 396-407.

NEGER, F. W.
1908a. Ambrosiapilze. Ber. Deutsch. Bot. Ges. 26, 1908, pp. 735-754.
1908b. Die Pilzkulturen der Nutzholzborkenkäfer. Centralbl. f. Bakteriol. 20, 1908, pp. 279-282.
1909. Ambrosiapilze II. Die Ambrosia der Holzbohrkäfer. Ber. Deutsch. Bot. Ges. 27, 1909, pp. 372-389.
1911. Zur Uebertragung des Ambrosiapilzes von *Xyleborus dispar F.* Naturw. Zeitschr. f. Forst. u. Landwiss. 9, 1911, pp. 223-225.

NEWCOMER, E. J.
1912. Some Observations on the Relations of Ants and Lycænid Caterpillars, and a Description of the Relational Organs of the Latter. Journ. N. Y. Ent. Soc. 20, 1912, pp. 31-36, 2 pls.

DE NICÈVILLE, L.
1890. The Butterflies of India, Burmah and Ceylon. 3. Calcutta, 1890.

OHAUS, F.
1899—1900. Bericht über eine entomologische Reise nach Zentralbrasilien. Stett. Ent. Zeitg. 60, 1899, pp. 204-245; 1900, pp. 164-191, 193-274.
1909. Bericht über eine entomologische Studienreise in Südamerika. Stett. Ent. Zeitg. 70, 1909, pp. 3-139.

PACKARD, A. S.
1881. Insects Injurious to Forest and Shade Trees. Bull. No. 7, Dep. Inter. U. S. Ent. Com., Washington, 1881, 275 pp. 100 figs.

PERRIS, E.
1852—1862. Histoire des Insects du Pin Maritime. Ann. Soc. Ent. France (2) 10, 1852, pp. 491-522, pl. (3) 1, 1853, pp. 555-644; 2, 1854, pp. 85-160, 593-646; 4, 1856, pp. 173-257, 423-486; 5, 1857, pp. 341-395, pl. Suppl. (4) 2, 1862, pp. 173-243, pl.
1876. Larves de Coléoptères. Ann. Soc. Linn. Lyon. 22, 1786, pp. 259-418.

DE PEYERIMHOFF, P.
1902.—1903. Descriptions des Larves de Trois Coléoptères Exotiques. Ann. Soc. Ent. France, 71, 1902-03, pp. 710-718, 6 figs.

PICARD, F.
1919. Contribution a l'Étude du Peuplement d'un Végétal. La Faune Entomologique du Figuier. Ann. Serv. Epiphyt. 6, 1919, pp. 35-174, 36 figs.

PIERCE, W. D.
1917. A Manual of Dangerous Insects Likely to be Introduced in the United States through Importations. U. S. Dep. Agric. 1917, 256 pp., 48 pls., 107 text figs.

REDI, F.
1671. Experimenta circa generationem Insectorum. Amstelodami, 1671.

RIGNANO, E.
1920. Psychologie du Raisonnement. Paris, F. Alcan, 1920. (First Chapter translated and entitled "On the Mnemonic Origin and Nature of Affective Tendencies." Monist 221, 1911, pp. 321-356.)

REITTER, E.
1911. Fauna Germanica. Die Käfer des deutschen Reiches, III Bd. Stuttgart, K. G. Lutz, 1911.

REIMARUS, H. S.
1798. Allgemeine Betrachtungen über die Triebe der Thiere, hauptsächlich über ihre Kunsttreibe. Hamburg, C. E. Bohn, 1798.

RÜBSAMEN, E. K.
1899. Ueber die Lebensweise der Cecidomyiden. Biol. Centralbl. 19, 1899, pp. 529, 561.

SCHNEIDER-ORELLI, F.
1911a. Die Uebertragung and Keimung des Ambrosia-Pilzes von *Xyleborus (Anisandrus) dispar* F. Naturw. Zeitschr. f. Forst- und Landwiss. 9, 1911, pp. 186-192, 223-225.
1911b. Ueber die Symbiose eines einheimischen pilzzüchtenden Borken-Käfers *(Xyleborus dispar* F.) mit seinem Nährpilz. Verh. Schweiz. Naturf. Gesell. 94, 1911, pp. 279, 280.
1912. Der ungleiche Borkenkäfer *(Xyleborus dispar* F.) an Obstbäumen und sein Nährpilz. Naturwirtsch Jahrb. Schweiz. 1912, pp. 326-334.
1913. Untersuchungen über den Pilzzüchtenden Obstbaumborkenkäfer *Xyleborus (Anisandrus) dispar* und seinen Nährpilz. Centralbl. Bakter. Parasit. 38, 1913, pp. 25-110.

SMITH, J. B.
1909. The Insects of New Jersey. Ann. Rep. N. J. State Museum, 1909.

SMITH, S. AND GUTHRIE, E.
1921. Chapters in General Psychology. Seattle, University of Washington Press, 1921.

SPRUCE, R.
1908. Notes of a Botanist on the Amazon and Andes. 2 vols. N. Y., Macmillan & Co., 1908. (Chapt. 24, "Ants and Plant Structure," being a paper submitted and read to the Linn. Soc., Apr. 15, 1869, but not published.)

STITZ, H.
1913. Ameisen aus Brasilien, gesammelt von Ule. Deutsch. Ent. Zeitschr. 1913, pp. 207-212, 2 figs.

SULC, K.

1909. Zur Anatomie der Cocciden. Zool. Anzeig. 34, 1909, pp. 164-172, 4 figs.

THAXTER, R.

1914. On Certain Peculiar Parasites of Living Insects. Bot. Gazette 58, 1914, pp. 235-253, 4 pls.

1920. Second Note on Certain Peculiar Fungus Parasites on Living Insects. Bot. Gazette 69, 1920, pp. 1-27, 5 pls.

THOMANN, H.

1901. Schmetterlinge und Ameisen. Beobachtungen über eine Symbiose zwischen *Lycæna argus* L. und *Formica cinerea* Mayr. Inaug. Diss. Univ. Zürich, Chur, J. Casanova, 1901, 44 pp., 1 pl.

TUSLANE, L. R.

1844. Lègumineuses Arborescentes de l'Amérique du Sud. Arch Mus. d'Hist. Nat. 4, 1844, p. 160.

ULE, E.

1907. Ameisenpflanzen des Amazonasgebietes. In Karsten and Schenck's Vegetationsbilder 4. Reiche. Jena, 1907, 14 pp., 6 pls.

WASMANN, E.

1896. Die Myrmekophilen und Termitophilen. C. R. 3me Congr. Intern. Zool. Leyden (1895) 1896, pp. 411-440.

WEISSE, J.

1897 Biologische Mitteilungen. Deutsch. Ent. Zeitschr, 1897, pp. 389-395.

WHEELER, W. M.

1901. Microdon Larvæ in Pseudomyrma Nests. Psyche 9, 1901, pp. 222-224, 1 fig.

1918. A Study of Some Ant Larvæ, with a Consideration of the Origin and Meaning of the Social Habit among Insects. Proc. Amer. Philos. Soc. 57, 1918, pp. 293-343, 12 figs.

1921. A New Case of Parabiosis and the Ant Gardens of British Guiana. Ecology, 2, 1921, pp. 89-103, 3 figs.

WHEELER, W. M. AND BAILEY, I. W.

1920. The Feeding Habits of Pseudomyrmine and Other Ants. Trans. Amer Phil. Soc. N. S. 22, 1920, pp. 235-279, 5 pls., 6 text-figs.

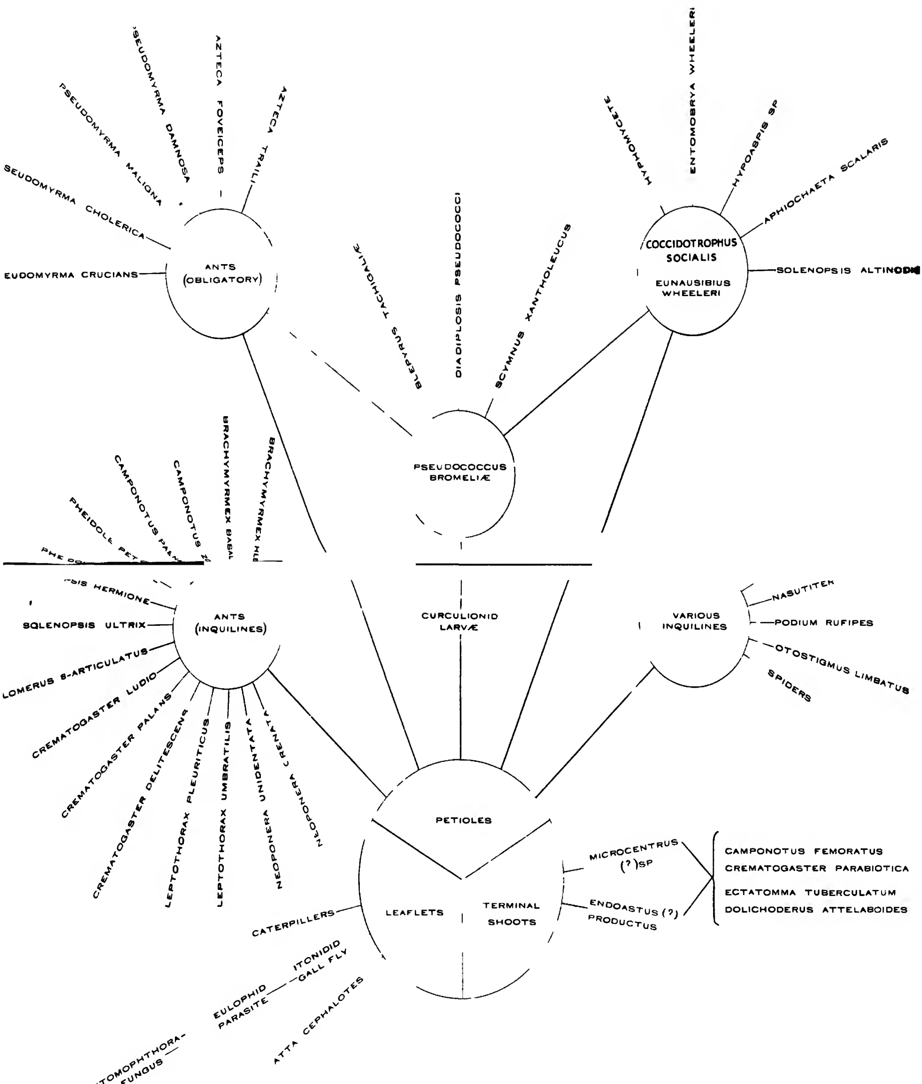
WHITE, F. B.

1872. Contributions Towards a Knowledge of the Life-histories of Certain Coleoptera. Ent. Month. Mag. 8, 1872, pp. 196-198.

WICKHAM. H. F.

1920. A Catalogue of the North American Coleoptera Described as Fossils. In Leng's Catalogue (q. v) pp. 349-365.

PLATE I YOUNG *TACHIGALIA FORMICARUM* HARMS, FROM LETICIA, PERU.
From a photograph taken by E Ule and reproduced from Plate V of his article in Kartsen and Schenck's Vegetationsbilder 4 Reihe 1907



TACHIGALIA BIOCOENOSE

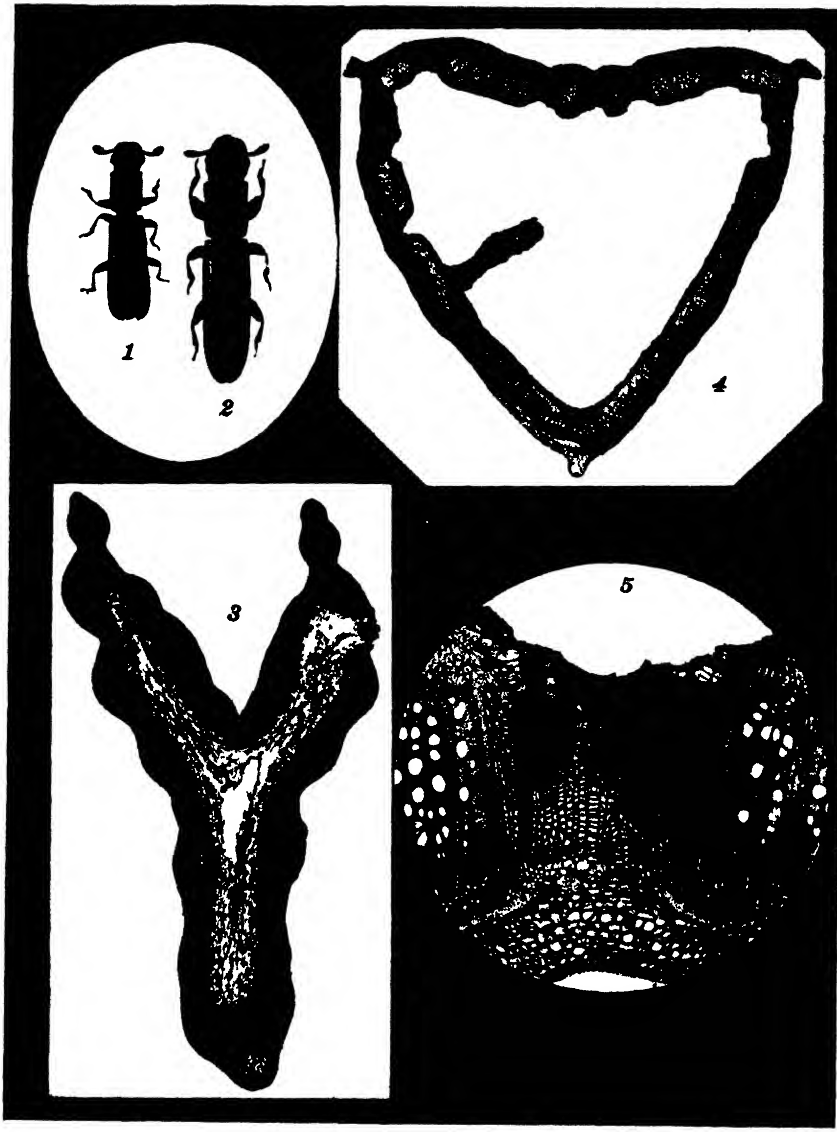


PLATE III.

Fig. 1. *Eunausibius wheeleri* Schwarz and Barber. X 8.
Fig. 2. *Coccidotrophus socialis* Schwarz and Barber. X 8.
Fig. 3. Cross section of base of very young petiole of adult *Tachigalia*, showing pith still in the cavity. Photograph by Prof. I. W. Bailey.
Fig. 4. Cross section of base of large petiole of *Tachigalia* inhabited by *Pseudomyrma damnosa*. The dark areas in the wall are nutritive parenchyma, which is not disturbed by the ants but nourishes their coccids. A portion of one of the carton partitions is shown on the left side. Photograph by Prof. I. W. Bailey.
Fig. 5. Cross section through one of the strands of nutritive parenchyma showing the cells with their homogeneous, amber-colored contents. Photograph by Prof I. W. Bailey.

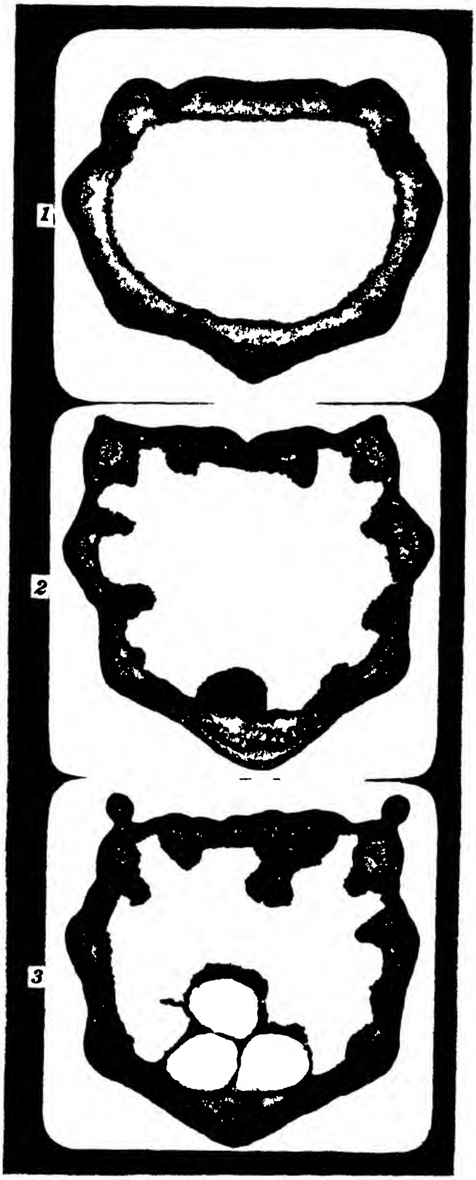


PLATE IV

Fig 1 Cross section of an as yet uninhabited petiolar swelling of a young *Tachigalia*, showing the intact nutritive parenchyma, large pith cavity, and thin layer of pith cells lining it. Photograph by Prof I W. Bailey.

Fig 2 Cross section of a petiolar swelling inhabited by *Coccidotrophus socialis* showing the gnawed nutritive parenchyma and the frass ridges. Photograph by Prof I W Bailey

Fig 3 Section similar to that of Fig 2 but showing three *Coccidotrophus* cocoons in cross section Photograph by Prof I W Bailey

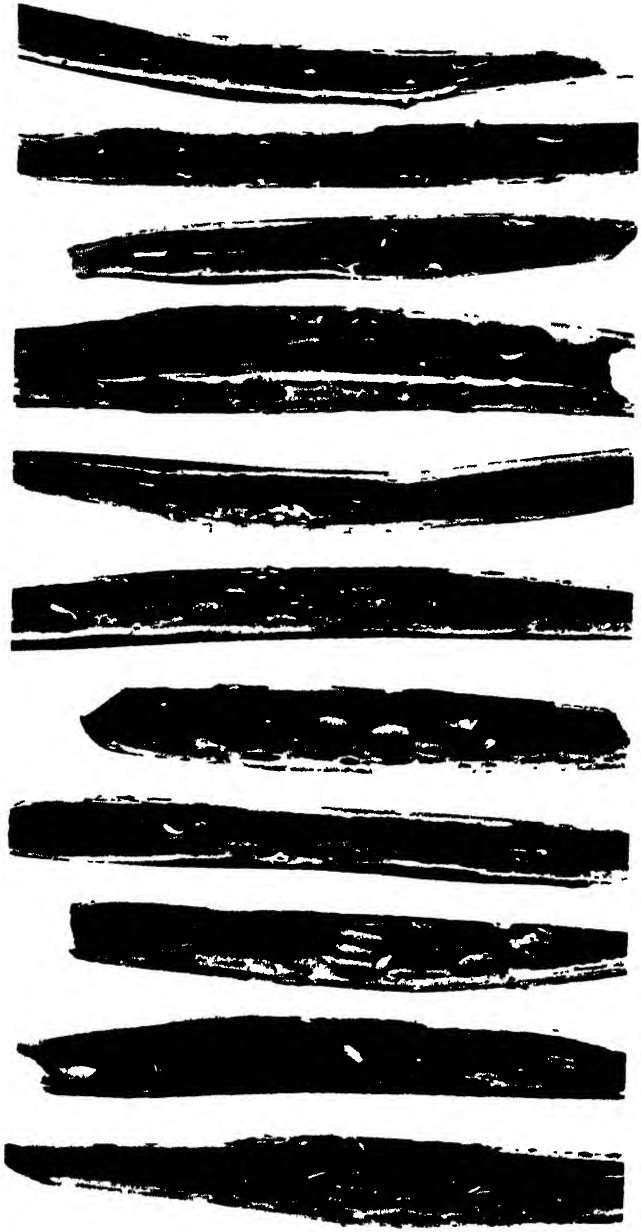


PLATE V.

Halves of various *Tachigalia* petioles seen from the inside, showing the arrangements of the cocoons, frass ridges, entrances, and in some cases also the beetles, larvæ and coccids and a pupa (second figure from below).

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 4

(Tropical Research Station Contribution Number 98)

THE TACHIGALIA ANTS

By WILLIAM MORTON WHEELER

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

DECEMBER 24, 1921

THE TACHIGALIA ANTS

By William Morton Wheeler

The early botanists Aublet (1775) and Spruce (1869, 1908), who first observed and collected *Tachigalia* in the forests of the Guianas and adjacent regions mentioned ants as inhabiting the swollen petioles but made no effort to have the species identified. As we have seen, Aublet coined the name of the plant from "tachi," the general native-name for the stinging ants of the genus *Pseudomyrma.* The white settlers of British Guiana call them "long John ants," but since the term "long John" is applied to the trees of the genus *Triplaris,* the "palo santo" of the Latin Americans, I have been unable to ascertain whether the name of the tree is derived from that of the ant or *vice versa,* for the tree is very tall and slender and the ants which inhabit its cavities are long and narrow. "Tachi," which is also used by the natives of Brazil for various species of *Pseudomyrma,* would seem to be the best name to introduce into the vernacular for all the species of *Pseudomyrma.*

For more precise knowledge of the ant-fauna of *Tachigalia* we are indebted to Ule (1907), who carefully collected the ants of this and many other myrmecophytes and turned them over to Forel to describe. In 1904 the eminent Swiss myrmecologist published a comprehensive paper on Ule's material, comprising ants from various species of the following genera of myrmecophytes: *Tococa, Maieta, Pseudocatopsis, Triplaris, Sapium, Cordia, Coussapoa, Duroia, Tachigalia, Platymischium, Pterocarpus, Pterocladon, Schwartzia* and a peculiar *Polypodium*-like fern. He described, however, only two ants from *Tachigalia, Pseudomyrma latinoda* Mayr subsp. *tachigaliæ,* from the petioles and flower-bearing branches of *Tachigalia formicarum* Harms (Plate I.), collected by Ule at Tarapoto, Amazonas, and *Azteca tachigaliæ* from the petioles of an undetermined *Tachigalia* from Cerro de Escaler, in the mountains of Peru. Forel (1906) also recorded the *Ps. tachigaliæ* from the upper Rio Purus, Amazonas

(A. Goeldi and Huber). In 1912 he added *Ps. latinoda* var. *endophyta* from the Rio Ariramba, near the Rio Trombetas, Amazonas, basing the variety on specimens taken by A. Ducke in an unidentified *Tachigalia.* Stitz in 1912 records two additional ants taken by Ule in *Tachigalia* petioles: *Ps. picta* Stitz from Alto Acre, Brazil, and *Azteca brevicornis* Mayr from Rio Branco, Sierra de Maivasy, Brazil. I have been unable to find any other records of *Tachigalia* ants in the literature. Strangely enough, none of the five forms cited above occurs in the trees at Kartabo, but instead, the following forms, 28 in number, half of them belonging to new species, subspecies and varieties. I have no doubt that I could have greatly increased the number of species, had I been able to examine Tachigalias in other parts of British Guiana, or even in the Bartica District, had I been able to prolong my stay.

SUBFAMILY PONERINÆ.

1.—*Ectatomma tuberculatum* (Oliver).

This large, rather sluggish, yellow-brown ant, the well-known "kelep," which Dr. O. F. Cook several years ago attempted to introduce into Texas from Guatemala for the purpose of preying on the cotton-boll weevil, was occasionally seen resting on the terminal shoots of young Tachigalias along the Puruni trail at Kartabo. It evidently feeds on the honey-dew of the Membracids, but more frequently it visits other plants, and especially the conspicuous saucer-shaped nectaries on the petioles at the junction of the leaflets of various species of *Inga.*

2.—*Neoponera unidentata* (Mayr).

A single deälated female founding a colony in a *Tachigalia* petiole. This species nests normally in the hollow twigs of various other trees.

3.—*Neoponera crenata* (Roger).

A single deälated female founding a colony in a *Tachigalia* petiole. This species nests in the hollow twigs of other trees. It is very common at Kartabo.

SUBFAMILY PSEUDOMYRMINÆ.

4.—*Pseudomyrma damnosa* sp. nov.
(Fig. 13, a-c)

Worker. Length: 4.5-5 mm.

Head about one-quarter longer than broad, subrectangular, slightly narrower in front than behind, with feebly and evenly convex sides, and straight or very feebly convex posterior border, somewhat flattened above, in profile about three-fifths as high as long. Eyes rather small, only as long as their distance from the anterior border of the head, feebly convex. Mandibles stout, evenly convex, with two large apical and two or three indistinct basal teeth. Clypeus small and very short, convex but scarcely carinate in the middle, depressed on the sides, its anterior border very feebly sinuate in the middle, more strongly on each side. Frontal carinæ straight, subparallel, closely approximated, extending back to a line joining the anterior orbits. Antennæ short and rather slender; scapes scarcely incrassated apically, scarcely more than a third as long as the head, their tips reaching only to the anterior third of the inner orbits; first funicular joint longer than broad, constricted basally; joints 2-8 twice as broad as long, 9 and 10 somewhat longer in proportion to their width; terminal joint as long as the two preceding together. Thorax rather robust, shaped much as in *latinoda* Mayr and *arboris-sanctæ* Emery; pronotum with the neck as long as broad, evenly rounded above, concave on the sides but the dorsal surface not marginate laterally. Mesonotum flattened, broader than long, its anterior border strongly arcuate, its posterior border nearly straight. Mesoëpinotal constriction deep and abrupt. Epinotum longer than broad, a little broader in front than behind, in profile with the base horizontal and on a level with the pro- and mesonotum, distinctly longer than the sloping declivity, into which it passes through an even curve. Petiole from above subtriangular, about one and one-half times as long as broad, with straight sides; in profile about half again as long as high; the dorsal outline in profile concave anteriorly, the node evenly rounded and convex above, abruptly truncated behind; ventrally the surface is nearly straight, at its anterior end with a strong, compressed, acuminate tooth, directed downward but

not backward. Postpetiole from above twice as broad as the petiole, nearly twice as broad as long, very convex above, but strongly narrowed and constricted anteriorly where it bears on the ventral surface an acute downwardly directed projection, smaller than that on the petiole; middle of the ventral surface strongly protuberant. Gaster elongate; sting long. Legs rather slender.

Smooth and shining, especially the head, which is very sparsely punctate; on the thorax the punctures are smaller and somewhat denser, and the gaster is very finely and superficially punctate and therefore appears somewhat less shining than the head and pronotum. Mandibles at their tips very finely striate and with coarse, elongate punctures; cheeks and pleuræ finely and superficially punctate.

Hairs sparse, golden yellow, erect or suberect on all parts of the body, rather short on the whole, longest on the petiole. Pubescence fine, distinct on the gaster, postpetiole, petiole, pleuræ, tarsi, tibiæ, funiculi and gula, not concealing the surface but rendering it somewhat less shining.

Brownish yellow; mandibles reddish brown, with black teeth; ocellar region, sutures of thorax, petiole, postpetiole, a patch on the center of each segment of the venter, the mesopleuræ, the femora, except their bases and tips and sometimes portions of the tibiæ, varying from pale to dark brown or blackish, clypeus and adjoining portions of head pale, clear yellow.

Female. Length: 7.5-9 mm.

Resembling the worker, but the head longer, with less convex sides and somewhat larger and more convex eyes and ocelli. Mandibles convex as in the worker, their external borders not geniculate at the base. Thorax rather long, in the region of the wing-insertions scarcely as broad as the head. Mesonotum rather convex, as long as broad. Epinotum sloping, the base one and one-half times as long as the declivity, which is even more abrupt than in the worker. Petiole and postpetiole somewhat longer in proportion to their width. Wings narrow and rather short, only 6.5 mm. long.

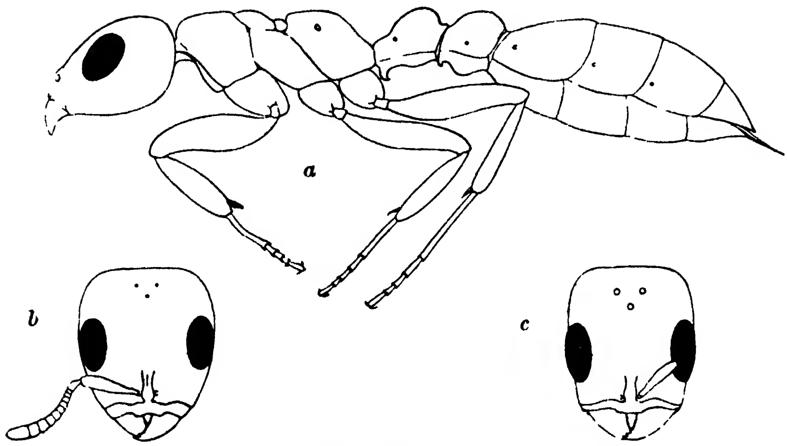


FIG 13 *PSEUDOMYRMA DAMNOSA* SP. NOV.
a, worker in lateral view; *b*, head of same from above; *c*, head of female from above.

Head less shining, the fine punctures anteriorly and the larger punctures on the vertex deeper and more conspicuous. Gastric segments with large scattered punctures.

Hairs and pubescence much as in the worker but the pubescence decidedly longer and more dilute, so that the gaster appears more shining.

Color yellow, like the worker, but with more numerous and more extensive spots. There is a brown spot on the middle of the pronotum anteriorly, one on the mesonotum posteriorly, the sides of the thorax have an irregular brown pattern, the petiole is sometimes entirely brown, more often with the surface of the node yellow; the ventral and anterodorsal portion of the postpetiole, a broad band on each gastric segment above and a large spot on each ventral sclerite, dark brown. All the femora and the middle and hind tibiæ, except their tips and bases, are also dark brown. In some specimens the dorsal banding of the gaster is more indistinct, in others the gaster may be described as dark brown with yellow posterior borders to the segments, less frequently the dark brown spot on the mesonotum becomes a Y with its branches extending to the anterior border of the sclerite. The scutellum and postscutellum are usually dark brown throughout. Wings pale fuscous, iridescent, with dark brown veins and pterostigma.

Male. Length: 5.5-6 mm.

Head through the eyes as broad as long, narrowed behind, with broadly concave posterior border; eyes and ocelli large; cheeks very short; mandibles well developed, with two larger apical and several indistinct basal teeth. Clypeus advanced and convex in the middle, its anterior border deeply sinuate on each side. Antennæ short; scapes twice as long as broad; first funicular joint as long as broad; joints 2-10 about twice as long as broad, terminal joint longer. Thorax shaped much as in the female, but the epinotum evenly rounded and sloping, without distinct base and declivity. Petiole and postpetiole like those of the worker but their ventral teeth are smaller. Gaster broadened, or clavate at the tip. Legs slender.

Surface of body less shining and less distinctly punctate than in the worker.

Pilosity and pubescence as in the female but less abundant.

Color of a duller brownish yellow; mandibles not darker; posterior portion of head, large spots on pleuræ, a large spot at the anterior end of the pronotum, lateral borders and a Y-shaped spot on the mesonotum, the epinotum, except its disc, the petiole, postpetiole and gastric segments, except the anterior and posterior border of each segment, the femora and tibiæ, except their tips and bases and the anterior tibiæ, dark brown. Venter yellowish, at least posteriorly; tips of genitalia infuscated. Wings colored as in the female.

Described from numerous specimens taken at Kartabo and the Penal Settlement, in the petioles of large specimens of *Tachigalia* growing in the sun.

This species is very closely related to *Ps. latinoda* Mayr and *arboris-sanctæ* Emery. The worker differs from that of the former, however, in its longer head, smaller and more flattened eyes, more approximated frontal carinæ and smoother and more shining surface. The var. *nigrescens* Mayr of *latinoda* approaches *damnosa* more closely, to judge from three workers from Pará received from Forel. The form described as var. *tachigaliæ* Forel, of which I possess a couple of cotypes, is much

more opaque, more brownish, with longer head and antennæ, larger eyes, more slender thorax, much more angular epinotum and feebler pilosity. The var. *endophyta* Forel resembles *damnosa* in coloration, but the description is very brief. In *arboris-sanctæ* the body and eyes are larger, the antennæ decidedly longer, the petiolar node more strongly truncated behind, with submarginate sides, the postpetiole is smaller and narrower, the color uniformly brownish yellow. *Ps. damnosa* is also closely related to *dendroica* Forel, but this form is larger, with a different sculpture and color, a different petiole, etc. Stitz's *Ps. picta,* too, is an allied form but, to judge from his figure, has very large eyes and a very different thorax, petiole and postpetiole. It is certain, nevertheless, that all the forms mentioned—*damnosa, latinoda, arboris-sanctæ, dendroica* and *picta*—as well as *triplaridis* Forel and the species *maligna,* described below, constitute a peculiar group of very closely related tachis confined to living myrmecophytes. One might regard the whole complex as a single highly variable species, but in the present state of our knowledge it is advisable not to indulge in too much "lumping" in the genus *Pseudomyrma.*

5.—*Pseudomyrma maligna* sp. nov.
(Fig. 14 a-c)

Worker. Length: 4-4.6 mm.

Very similar to the preceding species but slightly smaller, head somewhat broader and shorter, eyes distinctly smaller, less elongate and more flattened; ocelli smaller and further apart; mandibles more flattened with less curved external borders, frontal carinæ less approximated, antennal scapes shorter and more incrassated towards their tips. Clypeus sharply carinate, depressed on the sides, its anterior border emarginate laterally, produced in the middle as a short, transverse lobe, with feebly concave margin and sharp corners. Thorax shorter and more robust than in *damnosa;* pronotum broader, more convex on the sides and above; mesoëpinotal impression shorter but quite as deep; epinotum decidedly shorter, the base from above subhexagonal, broader behind than in front, and almost marginate on the sides, more flattened, appearing straight in profile. the declivity of the same length and forming with the base a more

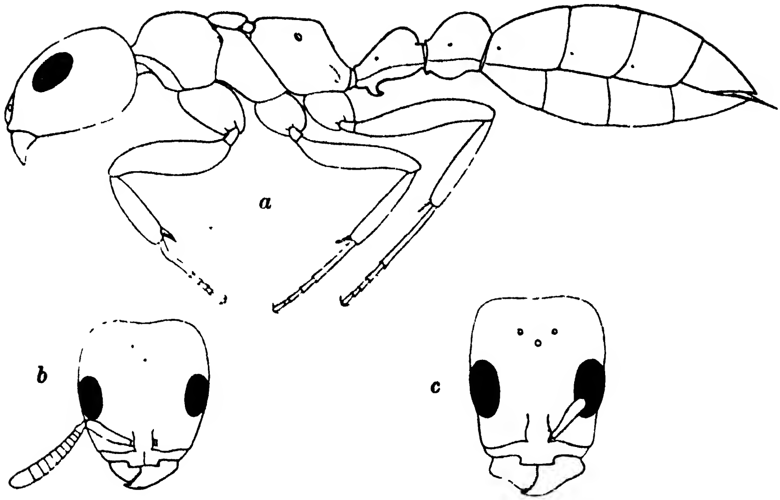


FIG. 14. *PSEUDOMYRMA MALIGNA* SP. NOV.
a, worker in lateral view; *b*, head of same from above; *c*, head of female.

distinct angle. Petiole shorter, only one and one-half times as long as broad, the node more rounded and more abruptly truncated behind, the spine at the anterior end of the ventral surface longer, more curved and hook-like. Postpetiole more convex above and at the sides, its anteroventral tooth less acute. Gaster more slender; legs somewhat shorter.

Surface of body even smoother and more shining than in *damnosa;* mandibles, head and thorax very smooth, with very small, shallow, uniformly scattered punctures; pedicel and gaster with even smaller and more indistinct punctures.

Hairs pale yellowish, short, uneven and similar to those of *damnosa* but much less numerous. Pubescence shorter and more dilute, so that it does not dim the shining surface of the gaster, longer and more distinct on the tibiæ and tarsi.

Deep castaneous; mandibles, clypeus, cheeks, antennæ, pronotum usually, sides of epinotum, petiole and postpetiole, wholly or dorsally, sides and bases of the gastric segments, legs, except the middle portions of the femora of all the pairs and of the tibiæ of the middle and hind pairs, yellowish brown. In some specimens the pronotum is also more or less castaneous above and

in some the fore legs are brownish yellow throughout. There is also considerable variation in the coloration of the petiole, postpetiole and gaster. In some specimens the petiole is entirely castaneous and only the node of the postpetiole is yellowish brown, or the yellowish brown at the bases of the gastric segments may be much reduced. The whole epinotum may also be castaneous in dark individuals.

Female. Length: 7.5-8.5 mm.

Head one and one fourth times as long as broad, subrectangular, slightly narrower in front than behind, with rather straight sides and feebly and broadly excised posterior border. Eyes and ocelli larger and more convex than in the worker. Mandibles short, with the external borders, abruptly geniculate at the base, the upper surface flattened, their apical borders with two sharp terminal and no basal teeth. Epinotum rounded, but with distinct, subequal base and declivity. Petiole one and two-third times as long as broad, the node somewhat depressed above, its sides rather bluntly submarginate, its ventral tooth large; postpetiole nearly as long as broad, less than twice as broad as the petiole. Gaster elongate. Wings narrow and short (6 mm.).

Sculpture much as in the worker, but mandibles striatopunctate and anterior portion of head more opaque and more densely punctate.

Pilosity and pubescence as in the worker.

Black; mandibles castaneous red; antennæ brownish yellow; the scapes sometimes slightly infuscated in the middle; clypeus, gula, pronotum and sutures of the thorax more or less castaneous; lateral borders of the ventral and dorsal sclerites of the gaster, tarsi and tibiæ brownish yellow; the middle and hind tibiæ infuscated in the middle of their extensor surfaces; femora blackish, with brownish tips and bases. Wings grayish hyaline, iridescent, not infuscated, with very distinct blackish veins and pterostigma.

Male. Length: 7.4-7.6 mm.

Head through the eyes as long as broad, eyes and ocelli larger than in *damnosa;* antennal scapes and first funicular joint, decidedly longer. Clypeus strongly carinate, slightly pro-

jecting in the middle, its sides impressed, their anterior borders bisinuate. Head behind the eyes narrowed but more convex and rounded than in *damnosa.* Epinotum somewhat longer and slightly more angular in profile, the ventral spine of the petiole much larger, nearly as large as in the female, the terminal dorsal segment of the thorax of a different shape, its posterior border produced as a narrow blunt point in the middle.

Shining, like the worker; even the mandibles and head very smooth and shining, the former striolate at the tips, punctate at the base, the head more densely punctate anteriorly as in the female.

Pilosity and pubescence much as in the worker.

Black; mandibles testaceous, infuscated at the base; antennæ fuscous, first funicular joint and tips and bases of scapes yellowish. Thoracic and abdominal sutures brown. Legs yellowish or pale brown, the femora, except their tips and bases, dark brown, the extensor surfaces of the hind tibiæ infuscated. Wings as in the female.

Described from many specimens from Kartabo, nesting, like the preceding species, in the petioles of large Tachigalias. Though closely related to *damnosa, arboris-sanctæ,* etc., this species seems to me to be specifically distinct. It also resembles *triplaridis* Forel and another species, which is found in *Triplaris surinamensis* near Kartabo and will be described elsewhere. Among my material there are also two varieties of *maligna* found nesting in some of the smaller Tachigalias; namely:

6.—*Pseudomyrma maligna* var. ***cholerica*** var. nov.

Worker. Length: 3-3.5 mm.

Distinctly smaller than the typical form and similarly colored, but the lighter parts are more extensive and often of a more washed-out, sordid yellow, whereas the darker parts are more piceous or blackish. The clypeus, cheeks, petiole and postpetiole are pale yellow, as are also the thorax, except the base of the epinotum and a fuscous cincture in the mesonotal region. The gula and first gastric segment are apt to be paler than the

upper surface of the head. Except in size, this variety is not very sharply marked off from the type.

7.—*Pseudomyrma maligna* var. **crucians** var. nov.

Worker. Length: 3-3.5 mm.

Of the same size as the preceding variety but with a decided tendency to melanism, the whole thorax, pedicel and gaster being very dark brown or black in mature specimens. The middle of the scapes is infuscated and there may be occasionally pale markings on the node of the postpetiole and at the bases and sides of the gastric segments.

SUBFAMILY MYRMICINÆ.

8.—*Pheidole cramptoni* Wheeler subsp. **petiolicola** subsp. nov.

Soldier. Length: 2.3-2.6 mm.

Decidedly smaller than the type, which measures 4 mm., and differing as follows: head with the anterior corners even more decidedly turned outward, anterior gular teeth more slender and more acute; eyes slightly larger and distinctly convex (flat in the type); antennæ shorter, the tips of the scapes reaching the lateral borders of the head two-fifths of their length from the anterior corners (nearly half their length in the type). Thorax shorter and proportionally stouter; epinotal spines slightly shorter; postpetiolar node hemispherical and evenly convex above, without distinct anterior angles. Interrugal spaces on the anterior portion of the head less distinctly reticulate, so that the rugæ seem to be sharper. Surface of the body smoother and more shining. Pilosity quite as well developed as in the type. Color more vivid but the dark and light areas distributed in the same manner. Mandibles and clypeus red, with dark brown borders; anterior two-thirds of head clear ivory yellow, with a large elongate castaneous spot between the frontal carinæ; posterior two-thirds of head with a band extending forward on each side to the eye; the thorax, petiole, postpetiole and gaster rich castaneous, the first gastric segment, femora and pleuræ somewhat paler; frontal carinæ, tibiæ and antennæ reddish; tarsi yellowish.

Worker. Length: 1.4-1.6 mm.

Slightly smaller than the worker of the typical form, somewhat darker brown, with distinctly shorter antennæ, the scapes reaching back beyond the border of the head only to a distance equal to their greatest diameter. Head shorter, with more distinct posterior corners. Epinotal spines somewhat smaller.

Described from several specimens found with brood in a young *Tachigalia* petiole near Kartabo. The types of the species were collected by Dr. F. A. Lutz at Kaieteur, British Guiana.

9.—*Pheidole tachigaliae* sp. nov.

Soldier. Length: about 2 mm.

Head large, subrectangular, about one-quarter longer than broad, as broad in front as behind, with rather straight, subparallel sides and deeply, angularly excised posterior border, vertex with a large and rather deep impression, without a median groove between it and the frontal area where the head is uniformly convex. Gular teeth small and blunt. Eyes small and moderately convex, only about their own length distant from the clypeus. Frontal carinæ long, very far apart, curved, gradually diverging behind towards the posterior corners of the head, forming the inner borders of broad, shallow, but distinct scrobes for the antennæ. These scrobes and the frontal carinæ reach nearly to the posterior corners of the head. Mandibles stout and very convex, with a pair of blunt, apical teeth. Clypeus flat, ecarinate in the middle, its anterior border somewhat retuse, feebly sinuous in the middle and on each side. Frontal area rather large, triangular, shallow, with a small median pit. Antennæ slender, scapes curved, not incrassated or flattened but slightly enlarged distally, reaching nearly to the middle of the lateral borders of the head; antennal club somewhat shorter than the remainder of the funiculus, its two basal joints subequal, broader than long, together equal to the terminal joint; first funicular joint large; joints 2-6 small and transverse. Thorax very short, broad through the humeri which are prominent and subangular; promesonotal suture distinct but not impressed. In profile the pro- and mesonotum form together a high hemispherical mass, the mesonotum descending abruptly

behind to the pronounced mesoëpinotal constriction. Epinotum small and low, subcuboidal, broader than long, in profile with subequal base and declivity, the former straight and horizontal in profile, the latter very steep and concave, the spines very small and acute, scarcely longer than broad at their bases, directed backward and very slightly upward. Petiole slender, pedunculate, the node at its posterior end abrupt, anteroposteriorly compressed, its border moderately sharp, transverse and very feebly sinuate in the middle. Postpetiole slightly broader than the petiolar node, transverse, with rounded sides. Gaster oval, about as large as the head, convex above and below. Legs moderately long, with thickened femora and tibiæ.

Shining; mandibles and middle of clypeus smooth, the former with coarse, scattered, piligerous punctures; antennal scrobes reticulate; remainder of head longitudinally rugose, the rugæ rather straight and subparallel extending to the posterior corners, the interrugal spaces and posterior part of the head rather loosely reticulately rugose. Pro- and mesonotum smooth and shining above; pleuræ and epinotum more opaque, finely reticulate or punctate, as are also the ventral portions of the petiole and postpetiole; the nodes of the latter, the gaster and legs smooth and shining.

Hairs pale, golden yellow, erect, of uneven length, moderately abundant, rather uniformly covering the dorsal surface of the body. Pubescence almost absent.

Reddish yellow; gaster and appendages paler yellow, the former with a brown transverse band or cloud on the posterior portion of each segment. Mandibles red, with black borders; clypeal border also blackish. Impression on the vertex with a small, indistinct brown spot.

Worker. Length: 1-1.1 mm.

Head subrectangular, as long as broad, its sides rather rounded, its posterior border feebly but distinctly emarginate in the middle. Eyes rather large, flat, in front of the middle of the head. Mandibles with oblique, indistinctly denticulate apical borders. Frontal area obsolete. Clypeus rather convex in the

middle, the anterior border transverse, entire. Antennal scapes extending only very slightly beyond the posterior corners of the head. Thorax shaped somewhat as in the soldier, but the upper surface of the pro- and mesonotum more flattened. Epinotum longer than broad, with very minute, acute teeth. Petiole, postpetiole, gaster and legs resembling those of the soldier.

Mandibles smooth and shining, sparsely and indistinctly punctate. Clypeus, head, thorax, petiole and postpetiole subopaque, finely, densely and uniformly punctate; postpetiolar node slightly shining, gaster and legs very smooth and shining.

Pilosity like that of the soldier.

Brownish yellow; mandibles, appendages and gaster paler, yellow; the gaster without dark fasciæ.

Female (deälated). Length: 2.5 mm.

Head subrectangular, a little longer than broad, a little narrower in front than behind, with straight sides and posterior border. Frontal carinæ and antennal scrobes as in the soldier. Antennæ longer, the scapes reaching to the posterior third of the lateral borders of the head. Upper surface of head convex, without vertical impression. Ocelli rather far apart. Thorax elliptical, as broad as the head, the mesonotum and scutellum flat above. Epinotum very small and sloping, with small teeth. Petiole and postpetiole much as in the soldier; gaster larger and more elongate.

Sculpture, pilosity and color as in the soldier. There is a black spot on the ocellar triangle and the brown fasciæ on the gaster are broader and darker. Wing insertions blackish.

Described from specimens from a single colony with brood, taken August 23 at Kartabo from a petiole of a small *Tachigalia*.

This species is very peculiar on account of its small size and the antennal carinæ of the soldier and worker. In the latter particular it seems to approach *Ph. scrobifera* Emery of Costa Rica, but this species is decidedly larger, with much longer epinotal spines, quite different sculpture, etc.

10.—*Crematogaster (Orthocrema) limata* F. Smith var. *palans* Forel.

A single colony with two deälated females, of what I take to be this variety, was found August 6, nesting in a small *Tachigalia* petiole at Kartabo. The workers are smaller than those of the typical *limata,* possibly because the colony was young. The antennal scapes are longer than in the type from Panama, but Forel mentions specimens from Pará Brazil, with longer antennæ.

The female measures nearly 6 mm. and is very deep brown, almost black, with the mandibles, legs and antennal clubs yellowish brown, the femora and tibiæ somewhat infuscated in the middle. Head subrectangular, broader than long, nearly as broad in front as behind, with straight, subparallel cheeks as long as the eyes. Antennal scapes extending a short distance beyond the posterior corners of the head. Thorax a little more than twice as long as broad; slightly narrower than the head, elongate elliptical from above, the nearly vertical epinotum with a pair of slender, pointed spines, longer than broad at their bases. Petiole subelliptical, truncated behind, its posterior corners distinctly angular; in profile twice as long as high, with nearly flat dorsal surface and a small tooth at the anteroventral margin. Postpetiole as broad as the petiole, somewhat depressed above, truncated behind. Gaster rather large, convex on the sides and above, pointed behind and emarginate anteriorly. Legs moderately slender. Surface of body very smooth and shining. Mandibles smooth, with a few small, scattered, piligerous punctures. Cheeks, sides of front, sides and declivity of epinotum longitudinally striate; mesonotum with coarse, scattered, piligerous punctures, the punctures on the gaster quite as sparse, but smaller. Hairs golden yellow, moderately abundant, erect; of uneven length, most numerous on the head, well-developed on the scapes and legs.

12.—*Crematogaster (Orthocrema) limata* F. Smith subsp *ludio* Forel.

Two colonies with deälated females, taken August 10 and September 3 from petioles of young Tachigalias on the Cuyuni trail at Kartabo. The workers agree well with Forel's descrip-

tion and with specimens taken elsewhere in British Guiana by F. A. Lutz, F. M. Gaige and myself.

The female closely resembles that of the var. *palans*, but the head is longer, fully as long as broad and more narrowed anteriorly; the epinotal spines are shorter and stouter, not longer than broad at their bases, the posterior angles of the petiole are less acute, the mandibles are darker, the legs paler and more uniformly brownish yellow, the hairs on the body are whitish.

12.—*Crematogaster (Orthocrema) limata* F. Smith subsp. *parabiotica* Forel.

This subspecies was not found nesting in the petioles but attending Membracids on the shoots of young Tachigalias. As I have shown in another paper (1921) it commonly lives in parabiosis with *Camponotus femoratus* (*vide infra* p. 167) in the peculiar "ant-gardens" attached to the trunks and branches of trees in the moist jungle. Both species of ants forage together and when found on *Tachigalia* the workers intermingle on the shoots and are very friendly to one another and to the Membracids but very pugnacious when interfered with.

13.—***Crematogaster*** (***Orthocrema***) ***delitescens*** sp. nov.

Worker. Length 2-2.1 mm.

Head nearly circular, convex and rounded above, without distinct posterior corners; eyes moderately convex, situated just behind the middle of the sides, distant nearly twice their length from the anterior border of the head. Mandibles narrow, convex, their short apical borders with four small teeth. Clypeus convex in the middle, its anterior border slightly reflected, broadly and evenly rounded. Frontal carinæ short, subparallel. Antennæ slender; scapes extending a little beyond the posterior border of the head; funicular joints 2-8 as long as broad, ninth joint longer than broad; club slender, decidedly shorter than the remainder of the funiculus, its basal about two-thirds as long as its terminal joint. Thorax short; pro- and mesonotum together subtriangular from above, as broad as long; the pronotum flattened, marginate on the sides, the mesonotum very short and narrow, declivous,

strongly carinate on each side. Promesonotal suture feeble; mesoëpinotal suture distinct, but very short. Epinotum very short, sloping between the spines, which are slender, straight and acute, a little longer than the sides of the base, much shorter than their distance apart and directed backward and slightly upward. Petiole oblong, a little longer than broad, with parallel sides, constricted at the anterior end, the posterior corners projecting as minute tubercles. In profile it is about one and one-half times as long as broad, with very feebly convex dorsal and ventral surfaces and without a distinct anteroventral tooth. Postpetiole small, broader than long, the node entire, anteroposteriorly compressed. Gaster elongate triangular, tapering and pointed posteriorly, concave dorsally, convex ventrally, the anterior border of the first segment straight and transverse.

Shining: mandibles smooth, with a few small, scattered punctures. Head very smooth and shining, cheeks indistinctly striolate-reticulate. Clypeus with two sharp, longitudinal rugæ on each side, smooth and shining in the middle. Pronotum with a few longitudinal rugæ on the disc, abbreviated behind; mesonotum and epinotum subopaque, regularly and evenly reticulate. except the most posterior portion of the latter, which is smooth in the middle; pronotum on the sides, petiole and gaster smooth and shining; postpetiole with short longitudinal furrows above.

Hairs whitish, long, sparse, rather blunt but not clavate on the dorsal surface of the body; anterior surfaces of antennal scapes with a row of long, rather flexuous hairs. On the legs the hairs are very short, appressed and rather sparse.

Piceous brown; head and gaster darker; base of scape and of funiculus paler; mandibles and tarsi brownish yellow.

Female (deälated). Length 4.7 mm.

Head subrectangular, nearly as broad as long, and nearly as broad in front as behind, with rounded posterior corners and straight, parallel cheeks. Eyes at the middle of the sides, elongate. Antennal scapes scarcely reaching to the posterior corners of the head. Thorax from above elongate elliptical, decidedly narrower than the head; mesonotum one and one-third times as long as broad; epinotum abrupt, without base or

declivity, the spines of the worker represented by blunt angles on the sides. Gaster elongate, with subparallel sides, the first segment subrectangular, nearly as long as broad.

Smooth and shining, the epinotum between the angles reticulate, the node of the postpetiole smooth.

Hairs decidedly shorter than in the worker, more abundant on the head and thorax than on the abdomen.

Color much like that of the worker, but the thorax as dark as the head and gaster, except the anterior portion of the pronotum, the prescutellum and epinotum which are more castaneous.

Described from a female and several workers constituting a single small colony found July 24 nesting in the petiole of a young *Tachigalia* growing on the Cuyuni trail, near Kartabo.

This form approaches *C. sumichrasti* Mayr in many particulars but is, I believe, quite distinct, especially in the shape of the head, mesonotum and petiole, in the pilosity of the legs, color, etc. It also recalls forms like *limata* Smith, *brasiliensis* Mayr and *lutzi* Forel. The antennal club might be regarded as indistinctly three-jointed. The female is very small compared with the corresponding phase of the *limata* group. Mayr's *laevis* is also a closely allied form, but the petiole and median funicular joints of this species are shorter, the pro- and epinotum smoother, the color is paler, etc. I have three workers taken by Mr. F. M. Gaige at Castries, St. Lucia, W. I., which agree very closely with the types of *delitescens*.

14.—*Solenopsis altinodis* Forel
(Fig. 15, a-c).

Worker. Length 1.8-2.1 mm.

Head about one and one-sixth times as long as broad, subrectangular, as broad in front as behind, with straight posterior and very feebly convex sides. Eyes consisting of about a dozen ommatidia, well in front of the median transverse diameter of the head, and about four times their diameter from the anterior corners. Mandibles with evenly convex external borders, the

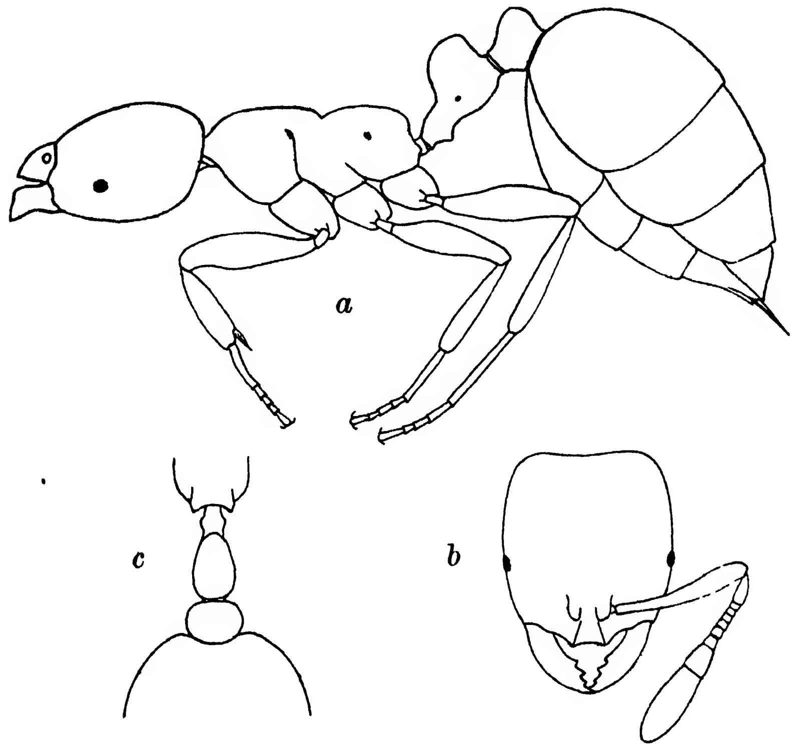


FIG. 15. *SOLENOPSIS ALTINODIS* FOREL, WORKER.
a, lateral view of body; *b*, head from above; *c*, petiole and post petiole from above.

apical borders oblique, with four distinct teeth. Clypeus projecting, with the usual pair of sharp carinæ. These do not end at the border in sharp teeth, but in small, rather blunt projections. Lateral denticles lacking. Frontal area distinct, impressed. Antennal scapes reaching nearly to the posterior fourth of the head. Funiculi about as long as the two-jointed club; joints 2-7 broader than long, 2-6 being fully twice as broad as long; basal joint of club a little longer than broad, somewhat less than a third as long as the terminal joint. Thorax slender; pronotum with subrectangular humeri and straight subparallel sides, in profile evenly and feebly convex above. Mesoëpinotal constriction short but pronounced; epinotum long, its base feebly convex, indistinctly bidenticulate behind and nearly twice as long as the

declivity which is abrupt and distinctly marginate on the sides. Petiole in profile very large, with distinct peduncle and longer abrupt node, which is much higher than the epinotum, higher than long, in profile subrectangular, with vertical anterior and posterior borders and subhorizontal superior outline rounded at each end. The ventral surface is convex behind and concave in front, with an angular projection but no distinct tooth near the anterior end. Seen from above the petiole is twice as long as broad, gradually enlarged behind, so that the node is seen to be much compressed laterally. Postpetiole in profile much higher than long, the summit of its node rounded, not attaining the height of the petiole. From above the postpetiole is somewhat broader than the petiole and slightly broader than long. Gaster large, the anterior border of the first segment somewhat concave. Sting long and powerful. Legs moderately long and slender.

Smooth and shining, with minute, scattered, indistinct, piligerous punctures; cheeks and sides of front finely striate.

Hairs pale yellowish, bristly, of uneven length, moderately abundant, erect or suberect, rather long on the body, shorter on the antennæ and legs.

Dull reddish brown; head and especially the gaster dark brown; mandibles, clypeus, cheeks, antennæ and legs yellow; middle portions of scapes, femora and tibiæ more or less infuscated.

I have redescribed this species, originally described from Venezuela and Trinidad, from many specimens taken at Kartabo. It does not live in the petioles of *Tachigalia* but in the ground and often enters those inhabited by the *Coccidotrophus* and *Eunausibius* and destroys their colonies (*vide supra* p. 82). I was never able to secure the sexual forms and brood. The worker is readily distinguished from the numerous other South American species of *Solenopsis* by the peculiar, high, compressed petiolar node, marginate and subbidentate epinotum, nearly unarmed clypeus and unusual coloration.

15.—*Solenopsis helena* Emery subsp. ***hermione*** subsp. nov.

Worker. Length 1.6-1.8 mm.

Differing from the typical *helena* of Chile in its somewhat greater size (*helena* measures 1.3-1.5 mm.), in having the head slightly shorter, with more rounded sides, joints 2-7 of the funiculus very slightly longer as compared with their width, so that the club is shorter in proportion to the remainder of the funiculus. The epinotum is evenly convex, without indications of an angle between the base and declivity, and the summit of the petiolar node is not so thick in profile. The eyes, which are not figured or described by Emery for the type, are very small and consist of only four ommatidia.

Female. Length 3.3 mm.

Differing from the typical *helena* in color, being yellow, like the worker, instead of pale brown, with the ocellar triangle, a broad dorsal band and a large ventral spot on each gastric segment dark brown. Each of these spots and bands is emarginate posteriorly. In old, deälated females the wing-insertions are also dark brown. Wings gray, rather opaque, with distinct brown veins and dark brown pterostigma.

Described from numerous specimens taken from several colonies found in the petioles of young Tachigalias along the Cuyuni trail at Kartabo. It nests also in the hollow twigs of various other plants.

16.—*Solenopsis helena* subsp. ***ultrix*** subsp. nov.

Worker. Length 1.6-1.8 mm.

Of the same size as the preceding subspecies but differing in having the head still broader in proportion to its length and with more rounded sides and posterior corners, the posterior margin straight or even slightly convex. The antennal scapes are distinctly longer, attaining the posterior fourth of the distance between the eyes and posterior corners of the head. Color pale piceous brown; tarsi and funiculi, except the clubs, pale whitish yellow; gaster dark brown, with the anterior and posterior borders of the segments yellowish.

Female (deälated). Length nearly 4 mm.

Distinctly larger than the female of *hermione* and of a different color, being castaneous brown; mandibles and clypeus pale reddish brown; antennæ and legs pale yellow, with the antennal clubs and scapes, femora and tibiæ, except their bases and tips, infuscated. Piligerous punctures on the head more distinct than in *hermione*. Epinotum in profile scarcely angular, but rounded as in that form and the typical *helena*.

Described from numerous workers and a single female taken from two colonies inhabiting the petioles of young Tachigalias at Kartabo. I have attached this form to *helena* though the shape of the head and the length of the antennal scapes are different. The other characters, however, such as the shape of the thorax and petiole, the sculpture and pilosity are so similar that it can hardly be regarded as a distinct species.

17.—*Leptothorax (Goniothorax) echinatinodis* Forel subsp. *aculeatinodis* Emery var. **pleuriticus** var. nov.

Worker. Length 2.2-2.5 mm.

Differing from the typical *aculeatinodis* in the following particulars: Head very dark brown or piceous, like the gaster; whole upper surface of the thorax ivory or brownish yellow, only the mesopleuræ and sides of the epinotum dark brown. Petiole pale, like the thoracic dorsum; postpetiole brown, paler than the gaster; scapes, base of funiculi, tarsi, tibiæ and bases and tips of femora pale ivory yellow, remainder of femora dark brown, as are also the clubs of the antennæ. Pilosity abundant, long, erect, present also on the scapes and legs, the hairs being obtuse but neither stout nor clavate. Rugæ of the petiole somewhat concentric. Tubercles on the petiole and postpetiole small and blunt. Epinotal spines long, slender, curved downward and directed upward, backward and outward, slightly shorter than the base of the epinotum.

Female. Length about 3 mm.

Head smooth and shining only in the middle between the frontal carinæ and imaginary lines continuing them to the posterior border of the head; lateral to these lines the surface

is coarsely, loosely and longitudinally rugose, with reticulate interrugal spaces. Thorax subopaque, its sides obscurely longitudinally rugose; mesonotum and scutellum longitudinally and rather regularly rugulose, the former somewhat smooth anteriorly. Epinotum punctate-rugulose, the declivity regularly traversely rugulose. Pilosity as in the worker. The spines of the epinotum are reduced to two stout teeth, as long as their width at the base. Petiole and postpetiole nearly smooth, except for their tubercles, which are decidedly smaller than in the worker. Gaster elongate elliptical, transversely truncated anteriorly. Brownish yellow; upper surface of head, except its posterior corners, antennal clubs, scutellum, postscutellum, sometimes a posteromedian spot on the mesonotum, femora, except their bases and gaster, except the anterior corners of the first segment, dark brown. Wings whitish hyaline, with very pale veins and distinct brown pterostigma.

Male. Length 2.2 mm.

Head distinctly longer than broad, with distinct posterior corners, the posterior orbits very near the median transverse diameter. Ocelli small. Cheeks very short. Clypeus with arcuate, projecting anterior border. Mandibles small, with oblique 3- or 4-toothed apical borders. Antennæ slender, 12-jointed; scapes reaching nearly to the posterior corners of the head; first funicular joint longer than broad, not broader than the remaining joints, which are somewhat fusiform; fifth joint long, representing two incompletely separated joints. Thorax long and slender, humeri distinctly angular; mesonotum with Mayrian furrows; epinotum low and sloping, moderately convex, without distinct base and declivity. Petiole smooth and slender, the node represented by a swelling in the middle, the sides with feeble traces of the lateral tubercles of the worker and female; postpetiole smooth, without tubercles, nearly as long as broad, broader behind than in front and distinctly broader than the petiole. Gaster and legs slender.

Head and thorax finely and densely punctate; vertex and mesonotum smooth and shining, as are also the pedicel, gaster and appendages.

Hairs whitish, short, less abundant and more delicate than in the worker and female; the longer hairs on the femora and tibiæ reclinate.

Piceous brown; head darker and more blackish; mandibles, antennæ, legs, genitalia and incisures of gaster pale brownish yellow. Wings as in the female.

Described from specimens belonging to a single colony inhabiting the petiole of a young *Tachigalia* at Kartabo (Sept. 3).

18.—***Leptothorax*** (***Goniothorax***) ***umbratilis*** sp. nov.

Worker. Length 1.7-2 mm.

Head subrectangular, very slightly longer than broad and slightly broader behind than in front, with nearly straight posterior border and very feebly convex sides; the eyes moderately convex, their posterior orbits at the median transverse diameter of the head. Mandibles convex, their apical borders with five or six small teeth. Clypeus distinctly concave in the middle, without carinæ, the anterior border entire and transverse in the middle, large but rounded and lobular. Mesoëpinotal impression distinct but shallow. Frontal groove absent. Antennæ 11-jointed; scapes reaching to within a distance equal to their greatest diameter of the posterior corners of the head; second funicular joint as long as broad, joints 3-7 distinctly broader than long; two basal joints of club subequal, longer than broad, together shorter than the enlarged terminal joint. Thorax shaped much as in *echinatinodis*, flattened above, marginate on the sides, with bluntly acuminate anterior humeral angles; lateral mesonotal angles rather acute, those at the base of the epinotum quite as large but rounded and lobular. Mesoëpinotal impression distinct but shallow. Epinotal spines short, stout and curved, not longer than their distance apart at the base, directed upward, backward and outward, much shorter than the base of the epinotum. Petiole about one and one-half times as long as broad, slightly broader behind than in front, with tubercles arranged as in *echinatinodis* but much smaller. In profile the petiole is longer than high, the node rather low, the peduncle short and indistinct; the ventral surface concave, with a small, downwardly directed tooth at the anterior end. Postpetiole broader than long, broader

than the petiole, high and convex above; its sides with two pairs of small tubercles, the anterior pair scarcely visible. Gaster and legs as in *echinatinodis*.

Mandibles shining, very finely striatopunctate. Clypeus nearly smooth in the middle, shining, longitudinally rugulose on the sides. Head, thorax and pedicel subopaque, the head densely and finely reticulate-rugulose, the rugules longitudinal; thorax with similar sculpture, the rugules on the pronotum somewhat more pronounced. Postpetiole with a few longitudinal rugæ. Gaster shining, the basal half of the first segment very finely shagreened and punctate, so that it appears slightly opaque or sublucid.

Hairs white, abundant, short, clavate and erect on the dorsal surface of the body. Such hairs are lacking, however, on the appendages where they are replaced by short, appressed pubesence.

Brown; upper surface of head, mesonotum, mesopleuræ, epinotum, nodes of pedicel and antennal clubs dark brown; mandibles, clypeus, scapes and tarsi yellow; pronotum and gaster brownish yellow.

Female (deälated). Length about 3 mm.

Resembling the worker. Pronotum more rectangular, its anterior border very straight and sharp, the corners acute. Mesonotum and scutellum flat; base of epinotum convex, bluntly angled on each side anteriorly, declivity longer, abrupt and concave, the spines of the worker represented by small, blunt angles. Petiole and postpetiole similar to those of the worker, but the tubercles on the sides of the latter longer and more acute. Gaster longer.

Sculpture much as in the worker; mesonotum as finely and regularly rugulose-punctate as the head; scutellum densely punctate; base of epinotum transversely rugulose-punctate. Gaster very finely striolate-punctate at base of first segment.

Pilosity like that of the worker.

Yellowish brown; mandibles, clypeus, tarsi and gaster yellow; ocellar region, scutellum and mesopleuræ dark brown.

Described from several workers and a female taken from a single colony nesting in a *Tachigalia* petiole at the Penal Settlement, near Bartica, August 10.

This species, though related to *L. tristani* Emery of Costa Rica, appears to be distinct both from it and the various forms of *echinatinodis* Forel in the structure of the clypeus, and petiole, in sculpture and coloration.

19.—*Allomerus octoarticulatus* Mayr.

Of this extraordinary little ant a single small colony with pupæ was found in a young *Tachigalia* on the Puruni trail at Kartabo. This I believe to be a very exceptional occurrence, since the species is the most typical and abundant tenant of another myrmecophyte, *Cordia nodosa,* so that I shall describe its peculiar habits in another publication in connection with the other ants which inhabit the stem-swellings of that plant and go to make up what may be called the "Cordia biocoenose."

20.—*Atta cephalotes* L.

I include this well-known leaf-cutting ant in the *Tachigalia* biocoenose, because on one occasion I found that it had completely defoliated some of the young Tachigalias growing near the Penal Settlement. The petioles of these plants were either empty or contained recently fecundated *Pseudomyrma damnosa* queens that had only begun to lay eggs, so that the plants were quite unprotected.

SUBFAMILY DOLICHODERINÆ.

21.—*Dolichoderus attelaboides* Fabr.

Workers of this singular ant were occasionally seen attending Membracids on the shoots of young Tachigalias growing along the Puruni trail, at Kartabo. The ant is more common in attendance on Membracids feeding on the terminal shoots of various Melastomaceæ.

22.—*Azteca traili* Emery.

A few workers and pupæ belonging to an incipient colony of this species were taken during September from a *Tachigalia* petiole at Kartabo. The species has been recorded by Forel and Emery from other myrmecophytes (leaf-sacs of *Tococa guianensis* and other Melastomaceæ, root-stocks of *Polypodium*).

23.—*Azteca foveiceps* sp. nov.
(Fig. 16, a-c)

Worker. Length 1.7-2.2 mm.

Closely related to *A. schumanni* Emery; practically monomorphic. Head flattened, about one and one-fifth times as long as broad, distinctly narrower in front than behind, with rather straight sides and excised posterior border. In the middle of the head above a small, shallow impression, or fovea. Eyes small, flat, less than twice their length from the anterior corners of the head. Mandibles curved, their apical borders with nine teeth, alternately larger and smaller. Clypeus feebly convex behind, flattened in front, with nearly straight, feebly bisinuate anterior border. Frontal area obsolete; frontal groove absent; frontal carinæ very short. Antennæ short and thick; scapes enlarged and somewhat flattened at the tip, reaching only to the middle of the distance between the posterior orbits and the posterior corners of the head; joints 2-10 of funiculi very short and transverse, the more basal fully three times as broad as long. Thorax short and stout, about twice as long as the transverse diameter of the pronotum. Sutures, especially the mesoëpinotal, pronounced and impressed; mesonotum as long as broad, convex but rising very little above the pronotum. Epinotum rounded subcuboidal, the base longer than the declivity, the former horizontal, the latter steep. Petiole small, the node high, squamiform, inclined forward, elliptical from behind, its border narrowed above, only moderately sharp in profile. Gaster elongate elliptical, the first segment short, with a deep impression anteriorly for the accommodation of the petiole. Legs stout.

Shining; very finely but not densely punctate; the punctures on the mandibles more distinct.

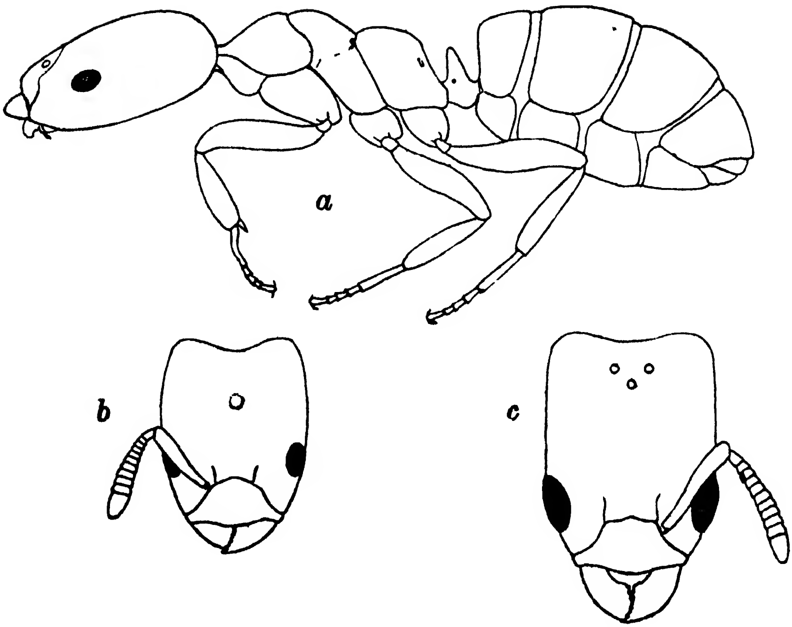


FIG. 16. *AZTECA FOVEICEPS* SP. NOV.
a, worker, lateral view; *b*, head from above; *c*, head of female.

Body and appendages covered with rather long, grayish, appressed pubescence, not sufficiently dense to obscure the shining surface; hairs yellowish, erect, rather short, abundant on the thorax, sparser on the head and gaster, short on the appendages.

Piceous black; borders of gastric segments paler; mandibles red; tarsal joints 2-5 and sides of clypeus yellowish brown; antennæ dark brown, their tips blackish, their insertions and the mouth yellowish.

Female. Length 4.5-4.8 mm.

Head decidedly longer and more nearly oblong than in the worker, about one and one-half times as long as broad, the sides straight and parallel, narrowed only near the clypeus. Eyes large, feebly convex, their distance from the anterior corners of the head less than half their length. Antennal scapes reaching

only one-third the distance from the eyes to the posterior corners of the head. Thorax broader than the head; mesonotum convex; epinotum rounded, convex, without distinct base and declivity. Petiole thicker, more erect, with much blunter superior border than in the worker.

Sculpture, pilosity and color as in the worker but the erect hairs are shorter and less abundant on the thorax. Wings distinctly and uniformly infuscated, with strong, dark brown veins and pterostigma.

Male. Length 1.6-1.8 mm.

Head through the very large eyes a little longer than broad, with extremely short cheeks, growing narrower behind the eyes, where the sides are nearly straight. Mandibles very small, atrophied, bluntly acuminate, edentate. Clypeus short, convex in the middle, with broadly and evenly concave anterior border. Scapes very small and short, scarcely more than twice as long as broad, constricted basally, somewhat swollen apically; first funicular joint globose, broader than the scape, succeeding joints somewhat longer than broad, growing successively shorter and narrower, longer at the tip. Thorax shaped much as in the female, but the epinotum more sloping; petiole broader, erect with its superior border blunter than in the worker but more acute than in the female. Legs rather slender.

Sculpture as in the worker and female; pubescence and especially the pilosity much shorter and sparser; appendages without erect hairs; antennal funiculi beyond the first joint clothed with fine, dense, erect, white hairs.

Dull, dark piceous brown; head darker; mouthparts and genitalia sordid yellowish. Wings as in the female.

Described from numerous specimens taken at Kartabo from the petioles of large, vigorous *Tachigalia* trees.

This species is so close to Emery's *schumanni*, that it may prove to be merely a subspecies of that form which was taken on the Rio Guainia, an affluent of the Cassiquiare, in Venezuela,

in the leaf-sacs of a Rosaceous myrmecophyte, *Hirtella guainiæ* Spruce (*ex* Hooker fil.).[1]

Emery saw only workers and a few very imperfectly preserved females of *schumanni*. His figures show, however, that the heads of both are decidedly shorter than in *foveiceps*, that the head of the worker is not so much narrowed anteriorly and that the antennæ are longer, with the median joints of the funicle less transverse, and the petiole of the worker more erect and with a smaller node.

SUBFAMILY FORMICINAE.

24.—*Brachymyrmex heeri* Forel.

Colonies of this minute honey-yellow ant with brood were repeatedly found in the petioles of young Tachigalias along the trails near Kartabo. More frequently it nests in dead stems of a very common Rubiaceous weed (*Spermacoce verbillata*), or in the twigs of bushes. It also occurs under the bark of old logs.

25.—*Brachymyrmex heeri* var. **basalis** var. nov.

Worker. Honey yellow, like the type, except the first gastric segment, which is black.

[1] This plant is cited by Emery in his Azteca monograph (1893) as "*Chrysobalanea hirtella* Guainiæ Hooker fil. but the "Index Kewensis" gives the name as cited above. It may be of interest to quote in this connection Spruce's remarks (1908, p. 395) on another species of *Hirtella* with ant-inhabited leaf sacs: "Examples of sac-like ant-dwellings exist in the leaves of plants of other orders, so like those already described in Melastomes, that it is scarcely worth while to do more than indicate some of the species. The solitary instance known to me in Chrysobalans is that of *Hirtella physophora* Mart., a slender arbuscle growing just within reach of inundations in the forest about the mouth of the Rio Negro. The distichous, oblong, apiculate leaves are nearly a foot long, and at the cordate base have a pair of compresso-globose sacs tenanted by ants. On cutting open the sacs I was rather surprised to find them lined with cuticular tissue and hairs, just like the underside of the leaf; which seems to show that they are produced by a recurvation of the alæ of the leaf, through the ants nestling at first (Aphis-like) under the leaf and causing it to become bullate, and that the recurved margins have at length reached and coalesced with the midrib so as to form a pair of scas." The fanciful explanation in the concluding sentence was evidently in part responsible for the unfortunate refusal of the Linnean Society to publish Spruce's very valuable paper when it was presented in 1869.

A single small colony with brood inhabiting the petiole of a small *Tachigalia* on the Puruni trail at Kartabo.

26.—*Camponotus (Myrmothrix) femoratus Fabr.*

On several occasions I found this very pugnacious ant attending Membracids on the young terminal shoots of small Tachigalias along the Puruni trail at Kartabo. As a rule the *femoratus* workers were accompanied by the workers of *Crematogaster limata* subsp. *parabiotica.* These two ants regularly live in parabiosis in the ant-gardens on the trees of the jungle, as I have shown in a previous paper (1921).

27.—*Camponotus (Myrmobrachys) zoc* Forel

This very active but timid species occasionally nests in the petioles of young Tachigalias but is more frequently found in the cavities of the dead twigs of other trees.

28.—*Componotus (Myrmobrachys) pittieri* Forel var. **pœnalis** var. nov.

Worker. Of a darker, more piceous brown color than the type from Costa Rica, the gaster being concolorous with the thorax and legs and not paler and more yellowish; the darker brown area on the top of the head is deeper and more extensive. The erect pilosity on the upper surface is distinctly sparser and the hairs on the legs and especially on the scapes are much more oblique, or reclinate. The base of the epinotum is more sloping so that the thorax is distinctly lower behind than in the type.

Female. Length about 6.5 mm.

Darker than the worker; front as well as the vertex of the head and also the scutellum, pleuræ and posterior portion of epinotum, dark chocolate brown; mandibles red, with black apical borders. Antennal funiculi not infuscated at the tip. Mesonotum rather flat above. Head, pro- and mesonotum subopaque, more strongly punctate than in the worker; scutellum, postscutellum and epinotum distinctly shining. Petiole with broader, more trans-

verse superior border when seen from behind, more acute in profile. Wings faintly infuscated, with light brown veins and conspicuous dark brown pterostigma. Pilosity similar to that of the worker but somewhat shorter, and the hairs on the funiculi and legs more appressed.

Described from specimens from a single colony found nesting with larvæ and cocoons in a petiole of a young *Tachigalia* at the Penal Settlement, near Bartica, August 10. This ant is evidently rare or very local, as I did not again take it in the vicinity of the Tropical Laboratory.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III, NUMBER 5

(Tropical Research Station Contribution Number 99)

NOTES ON THE HABITS OF EUROPEAN AND NORTH AMERICAN CUCUJIDAE (sens. auct.)

By WILLIAM MORTON WHEELER

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

DECEMBER 24, 1921

NOTES ON THE HABITS OF EUROPEAN AND NORTH AMERICAN CUCUJIDAE (sens. auct.)

By WILLIAM MORTON WHEELER

Family Silvanidæ Böving.

Oryzæphilus surinamensis L. (Fig. 7.) The "saw-toothed grain-beetle" the most abundant, most widely distributed and best-known species of the family.[1] It is cosmopolitan and gregarious; living in nearly all stored human foods of vegetable origin; cereals (rice, wheat, maize, barley, etc.), ground or unground or in the form of paste (macaroni), bread etc.; dried fruits, nuts, copra, more rarely in sugar, starch, drugs, tobacco, snuff or dried meats. The larva, which is very active, is also gregarious, living with the beetles and evidently capable of thriving on most of the substances mentioned (Glover, 1869; Guillebeau, 1890; Chittenden, 1895, 1897, 1911; J. B. Smith, 1909; Girault, 1912). When ready to pupate it may make a rude cocoon by agglutinating particles of food detritus with an oral secretion. The pupa is sometimes free, however, i. e., not inclosed in a cocoon, and is attached by its hind end to the shrivelled larval skin which has been previously attached to the substratum (Blisson, 1849; Coquerel, 1849; Chittenden, 1895). During the summer the whole life-cycle requires about twenty-four days, in spring from six to ten weeks. There are six or seven generations a year in the latitude of Maryland, and in that latitude it winters over as an adult (Chittenden, 1895). It seems to be present wherever the Indian-meal moth *(Plodia interpunctella)* is found (Chittenden, 1897) and has often been found living with another common grain-pest, the Curculionid *Calandra oryzæ* (Perris, 1853; Ganglbaur, 1899). In England and Scotland the beetle has been repeatedly taken out of doors

[1] I find that this or one of the closely allied species is figured by Redi (1671) who refers to it as "vermiculus qui condita arrodit" and "vermis conditorum et pharmacorum." Redi also figures the grain weevil, *Calandra oryzae*.

under the bark of trees (Fowler, 1889; Champion, 1896). "As an instance of unusual trouble caused by this insect may be mentioned the case cited by Taschenberg of the beetles having invaded sleeping apartments adjoining a brewery where stores were kept and annoying the sleepers at night by nipping them in their beds" (Howard and Marlatt, 1896).

Oryzaephilus mercator Fauvel.—The "merchant grain-beetle," very similar to the preceding, cosmopolitan, and recorded as living in and feeding on pea-nuts, English walnuts, wheat, corn-meal, cereipo fruit (*Myrospermum frutescens*), candle-nuts (*Aleurites moluccana*), and dried currants (Guillebeau, 1890; Chittenden, 1897, 1911). It has been taken under the bark of plane-trees in France, in the neighborhood of mills (Guillebeau). Champion (1896) records it as occurring in shipments of pea-nuts at Rouen in company with another grain-beetle, the Tenebrionid *Palorus subdepressus* Woll. "The close relationship of *mercator* and *surinamensis* makes reasonably certain their identity as regards development, nor is it probable that they differ in any degree in food-habits" (Chittenden, 1896).

Oryzaephilus bicornis Erich.—Cosmopolitan, but less widely distributed and more southern than *surinamensis*. Lives and breeds in wheat and dried figs in France; also taken in rubbish at the base of fig-trees (Guillebeau, 1890; Chittenden, 1897).

Oryzaephilus gossypii Chitt.—Cosmopolitan; breeding in cotton-seed (Chittenden, 1897).

Silvanus bidentatus Fabr.—Europe and United States (N. J., Ind., Conn., So. Cala., Fla.). Under chestnut bark in the United States (Glover, 1869). Recorded as occurring under bark of oaks and firs in England (Fowler, 1889), of firs in Germany (Reitter, 1911), of poplars, elms and figs in France (Picard, 1919). J. B. Smith (1909) records it as occurring under bark throughout New Jersey, as not rare, and as taken most of the season. According to Picard it has the same mode of life as the species of *Laemophloeus* (q. v.).

Silvanus gemellatus Duv.—Cuba and Southeastern States to New York. Lives and breeds in maize in the field as well as in granaries, also in wheat and over-ripe or dried fruits. It nearly

always first destroys the germ of the kernel and hence causes considerable injury to seed maize in the Southern States. "It is essentially an out of doors species, but when conditions favor its increase may become a serious pest in granaries, as it is capable of breeding from egg to adult in the short period of three weeks" (Chittenden, 1897, 1911).

Silvanus unidentatus Fabr.—Europe. Perris (1853, 1876) states that the larva is common in France under the bark of oak, poplar, chestnut and willow, rarer under pine bark. It is agile and photophobic and lives gregariously with the adult beetles among the detritus left by the larvæ of *Bostrychus*, Cerambycids and Buprestids. In Germany under elm bark (Kaltenbach, 1874); in Britain under bark of beech, oak, horn-beam, etc. (Fowler, 1889), of deciduous trees in general (Reitter, 1911).

Silvanus fagi Guèrin.—Europe. Under beech bark; in England in dead branches of fir (Fowler, 1889); in Germany under fir bark and fir-cones (Reitter, 1911).

Silvanus planatus Germ.—Eastern United States (N. J., Ind., Fla.). Under pine-bark in New Jersey (J. B. Smith, 1909).

Cathartus advena Waltl.—Cosmopolitan. Lives and breeds in stored wheat, rice, corn in stack, grain, meal, middlings, flour, dates, figs, lichi nuts, table beans, cacao-beans, edible tubers, etc., but apparently only when these substances are not kept dry and clean. "In breeding experiments recently conducted by the writer it failed to develop in fresh grain or meal, but bred freely in corn-meal which was moistened and produced mold. The beetles particularly fed freely on the molds, of which there were three or four species, and it would appear that this is the normal habit of the insect" (Chittenden, 1897). Pierce (1917) cites *C. advena* among the insects infesting teak in India, stating that it "breeds in leaves, forming galls, causing leaves to drop" *(sic!)*. Perris (1876) found the larva in lichi nuts in company with larvæ of *O. surinamensis*. Fowler (1889) states that *C. advena* is sometimes found out-of-doors in England and that Waterhouse took it under cut grass. In New Jersey it is "rare under bark; more common in stored grain, fruits, nuts, etc., particularly such as are spoiled" (J. B. Smith, 1909)

Cathartus cassiæ Reiche.—Cuba and Southern States. Glover (1869) describes the larva as feeding on maize kernels, near the germ, and also on the exposed seeds of cotton bolls. Doran (1892) found this beetle breeding in bran and middlings and producing a temperature 42 deg. F. higher than that of the room in which it was living!

Cathartus longulus Blatchley.—Indiana. "Sifted from borders of Sphagnum marsh" (Blatchley, 1910).

Cathartus excisus Reitter.—Taken in Germany in Havana tobacco (Ganglbaur, 1899; Reitter, 1911).

Cathartus quadricollis Guérin.—Imported into Germany in Havana tobacco and also in the fruits of *Cassia fistula* (Ganglbaur, 1899); imported in Havana cigars (Reitter, 1911).

Nausibius clavicornis Kug.—Cosmopolitan. "Under bark and in sugar" (Glover, 1869). "Often found on ships in plant wares. It also lives in old nests of South American bees" (Ganglbaur, 1899). Introduced into Britain, found in sugar, etc. (Fowler, 1889). In New Jersey under bark and also occasionally in store-houses (J. B. Smith, 1909). In Indiana "two specimens were taken with a dozen other species at sap beneath the bark of a soft maple tree. Leconte states that it occurs usually in rice, sugar and other articles of commerce throughout the United States" (Blatchley, 1910).

Telephanus velox Haldem.—United States (N. J., Ia., Ind., Conn.). "Very common under rubbish of all sorts and as its name implies, runs with remarkable swiftness" (Casey, 1884). "Occurs more often beneath stones, chunks and dead leaves than beneath bark. When exposed it usually remains quiescent with antennæ folded against sides; but if touched it runs with great swiftness, whence its specific name" (Blatchley, 1910). "Throughout the State (N. J.) under stones and old leaves; rarely under bark; may be sifted out from fall to late spring" (J. B. Smith, 1909).

Family Cucujidæ (Böving *emend.*)

Cucujus clavipes Fabr.—Atlantic States to Illinois and Iowa; a beautiful scarlet red insect, represented in the Pacific States

by the var. *puniceus* Mann. The larva is said to be predatory (Le Baron, 1874; J. B. Smith, 1909). Le Baron (1874) figures the larva; Dimmock (1884) records the adult beetle as occurring under decaying butter-nut bark. Hamilton (1886) gives the following account of the insect: "The very depressed form of this well known beetle indicates, *a priori,* its subcortical habit, and no other has power to adapt its tastes to a greater variety of timber—locust, maple, oak, hickory, gum, buckeye, etc.—are all alike to it. The larvæ do not eat the wood nor the bark, living apparently on the moisture existing between the two. They are elongate, much depressed, brownish yellow, and scarcely to be distinguished from those of *Dendroides canadensis*. Sometime in September, the larva having matured, constructs a circular cell from small particles of the decaying bark and wood, and in this completes its transformations before severe frost, but the beetle does not quit the cell till the following spring. I have never known any of these insects to be taken elsewhere than under bark, though they undoubtedly fly, being possessed of a good pair of wings. On the 10th of October, fifteen newly disclosed individuals and several pupæ were taken under the bark of a gum log; the latter are depressed like the beetle, pale at first, the eyes, antennæ and portions of the legs gradually changing to black, and the elytra becoming red after disclosure. This insect is annual."

Cucujus haematodes Erich.—Europe. In Germany under bark of maples, rarer under bark of fir-stumps (Reitter, 1911).

Cucujus cinnaberinus Scop.—Europe. Habits like those of *haematodes* (Reitter, 1911).

Dendrophagus crenatus Payk.—Europe. In Germany under oak bark; gregarious (Kaltenbach, 1874) ; in Britain under bark of fir *(Pinus sylvestris),* less frequently under bark of larch *(Larix europæa)* (White, 1872; Fowler, 1889). According to White the larva has been supposed to be carnivorous, but is truly phytophagous, feeding on the decaying inner bark of dead and usually prostrate trees of the species mentioned. The beetles are agile and seem to come out at night and run about on the bark. The eggs seem to be laid in the spring by hibernating females; the larvæ feed twelve to fourteen months, becoming pupæ during

the second summer, the beetles emerging in August. The larva is very quick and agile and when disturbed moves the hinder part of its body quickly from side to side. When about to pupate "it attaches itself firmly to a piece of bark by the thirteenth segment, and the pupa remains attached by its anal segment to the larva-skin." Perris (1876) believes that White is mistaken in his account of the food-habits of the insect, and that it is carnivorous or coprophagous, like *Brontes planatus* (q.v.).

Emporius signatus Frauenf.—Imported into Germany from the tropics in Havana cigars (Ganglbaur, 1899).

Pediacus depressus Herbst.—Recorded from Europe, Vancouver and the United States (So. Cala., Mich., Lake Superior, Colo., Pa., S. C.). In Britain under oak-bark, in mold-like fungus; also in stores on board a yacht (Fowler, 1899). Under bark of deciduous trees in Germany (Reitter, 1911).

Pediacus fuscus Erich.—Europe and North America, Alaska, Labrador, British America, Mich., Neb., Colo., N. Mex., Lake Superior, and probably cosmopolitan. In Germany under pine and oak bark (Reitter, 1911), and under the bark of firs (Kaltenbach, 1874). In Britain under bark and in chunks of freshly cut oak, beech and horn-beam (Fowler, 1889).

Brontes planatus L.—Europe. Perris (1853) describes the larva as livid reddish, punctate with carmine dots, and as being very agile and supple. In France it is common throughout most of the year under the bark of various trees, but most often under oak or pine bark. Perris believes the larva to be carnivorous, because it is always found among the larvæ of *Tomicus* or with Poduri or mites 'dont elle fait, sans doute, sa nourriture." "When about to pupate it attaches itself to a flat surface by means of the tubercle of its last segment, then the skin splits along the back and is pushed back to the posterior end of the body, where it remains much wrinkled." In Germany under bark of deciduous trees, especially of oaks (Kaltenbach, 1874; Reitter, 1911); in Britain under bark of dead beech trees (Fowler, 1889). According to Perris (1876) the larva is predaceous and a scavenger, living under the bark of various trees, including, chestnut, especially where the larvæ of other

beetles have lived. All the stages are passed through in several months, the young larvæ being found in the spring, the adults in late summer. The latter hibernate under the bark. According to Ganglbaur (1899) the larva is "undoubtedly carnivorous."

Psammoechus bipunctatus Fabr.—Europe. Recorded in Britain from marshy places at roots of grass and in refuse (Fowler, 1889); in Germany on the banks of streams or ponds under dead rushes (Ganglbaur, 1899; Reitter, 1911).

Psammoechus desjardinsi Guérin.—Cosmopolitan (Casey, 1884); Florida (Leng, 1920).

Family Laemophloeidæ Böving.

Laemophloeus alternans Erich.—Cosmopolitan; "found everywhere" (J. B. Smith, 1909). In Germany under bark of conifers in galleries of beetles of the genus *Pityogenes* (Reitter, 1911). In France occurring occasionally in the galleries of *Hypoborus ficus,* a bark beetle of fig-trees, but also in galleries of other bark beetles in other plants (Perris, 1853; Picard, 1919).

Laemophloeus ater Oliv.—Europe. In France in dead or dying stems of broom and gorse, preying on the larvæ of the bark-beetle *Hylesinus rhododactylus* (Perris, 1853). In dead stems of broom and under elm-bark in Britain (Fowler, 1889). Rare under bark; common in bran and middlings in Germany (Reitter, 1911). Occurs in France not only in the galleries of *Hypoborus ficus* in fig-bark, but also in the galleries of other Scolytids in other plants (Picard, 1919).

Laemophloeus biguttatus Say.—United States (Ind., Neb., Fla., So. Cala., N. J.). Throughout the State of New Jersey under bark; fall to mid-summer. (J. B. Smith, 1909.)

Laemophloeus bimaculatus Payk.—Europe. Under bark of oak, beech and horn-beam in Britain (Fowler, 1889); in Germany under beech bark (Reitter, 1911).

Laemophloeus castaneus Erich.—Europe. Under birch and chestnut bark in Germany (Reitter, 1911).

Laemophloeus corticinus Erich.—Europe. Under oak-bark in Germany (Reitter, 1911).

Laemophloeus clematidis Erich.—Europe. In *Clematis vitalba.* A constant companion of *Xylocleptes bispinosus,* feeding on the refuse and dejecta in its galleries (Perris, 1853; Kaltenbach, 1874; Reitter, 1911). In dead stems of *Clematis vitalba* in Britain (Fowler, 1889).

Laemophloeus denticulatus Preysl.—Europe. "The larvæ probably merely accompany the larvæ of really injurious xylophagous beetles. According to Hartig they are found in the cones of conifers, according to Ratzeburg also under dead bark, according to Hellwig and Panzer under the bark of linden trees" (Kaltenbach, 1874).

Laemophloeus dufouri Laboulb.—Europe. The larvæ were found by Perris (1853) under pine-bark hibernating in January with the pupæ and beetles in the galleries of *Crypturgus pusillus.* He believed that the larvæ feed on those of the *Crypturgus,* but more probably they merely eat the dejecta in the burrows.

Laemophloeus duplicatus Waltl.—Europe. Under bark of beech, oak, etc., in Britain (Fowler, 1889); in Germany under beech bark (Reitter, 1911).

Laemophloeus fasciatus Mels.—United States (Ind., Pa., Minn.). In Minnesota it "is found under bark, but is also very common near saw-mills, especially in those in which hardwood is sawed. In running over persons engaged in mills it will bite, even without provocation, and may cause bad sores" (Lugger, 1899).

Laemophloeus ferrugineus Steph.—Cosmopolitan (Casey, 1884). In Britain in hay-stack refuse, rarely under bark; also in granaries (Fowler, 1889). In Germany in rice, bran, middlings and meal (Ganglbaur, 1899; Reitter, 1911; Chittenden, 1911). "Its larva, which does not differ from that of other species of the genus, has been described by Carpentier (Bull. Soc. Linn. Nord. France, April, 1877, 3 pp. 239-241). It lives under the bark of oaks, cherry trees and, it is said, in fig-trees inhabited by wood-boring insects, but also in grain attacked by *Calandra,* in bran, flour, etc." (Picard, 1919).

Laemophloeus hypobori Perris.—Europe. (France). Living only in the galleries of a bark-beetle *Hypoborus ficus,* in fig-trees. Both the adult beetles and the larvæ live gregariously and feed on the dejections, exuviæ and all kinds of detritus which they find in the empty galleries. They occur more rarely in the brood galleries that are still inhabited by the parent *Hypobori.* Both larvæ and adults are found throughout the year and both stages, but especially the adults, are found hibernating (Picard, 1919). This author gives an excellent account of the beetle and its habits.

Laemophloeus juniperi Grouv.—Europe. Under bark of *Juniperus* in galleries of the bark-beetles *Phloeosinus bicolor* Br. and *thujæ* Perris (Reitter, 1911). "At Monpellier this is the rarest species in fig-trees; I know of only one capture made in August by J. Lichtenstein. *L. juniperi* is nevertheless common in Herault, as in the whole South. I often found it under the bark of elms riddled by *Pteleobius vittatus* and *kraatzi;* it is also found in the galleries of *Hypoborus (Liparthrum) mori* of the mulberry, of *Phloeosinus thujæ* and *bicolor* infesting *Juniperus, Cupressus, Thuja* and other conifers, of *Phloeotribus scarabaeoides* of the olive, etc." (Picard, 1919). The larva, which is coprophagous and detritivorous, has been observed and described from *Thuja* infested with *Phloeosinus thujæ* by Decaux (Bull. Soc. Ent. France, June 25, 1890, p. 125) and is redescribed by Picard.

Laemophloeus modestus Say.—United States (Tex., Fla., D. C., N. J.). "Taken in hemp-seed, the interior of which had been entirely eaten out" (Glover, 1869). In New Jersey occurring under bark and in siftings (J. B. Smith, 1909).

Laemophloeus monilis Fabr.—Europe. In Germany under beech and linden bark, gregarious in the burrows of *Tachrorhychus bicolor* (Reitter, 1911).

Laemophloeus perrisi Grouv.—Europe. Occurring in the fig. "It is also known from the *Lentiscus* and pines infested with *Pityophthorus.* This is a Corsican insect, very rare in France, where it has scarcely been seen, except in the Provence" (Picard, 1919).

Laemophloeus pusillus Schön—Cosmopolitan and common (Casey, 1884). In Britain in granaries, imported with grain (Fowler, 1889). Occurs commonly in cereals, but probably in the main predaceous and scavengering (Chittenden, 1911). In rice, grocery wares, etc., in Germany (Reitter, 1911).

Laemophloeus testaceus Fabr.—Europe. Similar to *L. denticulatus* but occurring under linden bark (Kaltenbach, 1874), and under dry beech bark (Reitter, 1911). Perris (1853, 1876) found the larvæ under oak bark in galleries of *Tomicus* and under chestnut bark with the larvæ of the bark beetle *Dryocoetes capronatus* on which it was preying, but also living on the dejections and capable of developing to maturity in the absence of the *Dryocoetes*. Also found under bark of dead oaks with the larvæ of the same Scolytid and in the elm in the galleries of *Hylesinus vittatus* and *kraatzi*.

Laemophloeus turcicus Grouv.—Cosmopolitan. Imported into Germany in dried fruits, especially prunes, from the orient (Reitter, 1911).

Laemotmetus ferrugineus Gerst.—Cosmopolitan. Imported into Germany in rice (Ganglbaur, 1899; Reitter, 1911).

Laemotmetus rhizophagoides Walker.—Cosmopolitan. Found in stored rice in Berlin, Germany (Chittenden, 1911).

Lathropus vernalis Erich.—United States (Fla., Miss., N. J., Conn.). Throughout New Jersey, secured by beating dead branches, May to July (J. B. Smith, 1909).

Lathropus sepicola Müller.—Europe. According to Perris (1876) the larva lives under elm-bark in the galleries of the bark beetles *Scolytus multistriatus, Hylesinus vittatus* and *H. kraatzi* and feeds on their dejections. The perfect insect emerges in May. Reitter (1911) often beat the latter from dry wood fences.

Phloeostichus denticollis W. Redtb.—Europe. Under the inner bark of maple-trees, together with the larval stages (Weisse, 1897; Reitter, 1911).

Prostomis mandibularis Fabr.—Europe and Pacific States (Or., Nev., Cala.) and Vancouver. In very rotten, damp wood

of deciduous trees. The larvæ are often present in great numbers with the beetles (Ganglbaur, 1899; Reitter, 1911). Perris (1876) found the larvæ in rotten chestnut wood and states that Curtis, Chapuis and Candèze took them in rotten oak wood.

Hemipeplus marginipennis Lec.—Cited only from Georgia and Florida (Leng, 1920). According to Schwarz a rather abundant species under palmetto bark (Casey, 1884).

Hemipeplus microphthalmus Schwarz.—Cited only from Florida (Leng, 1920), where it was taken flying at night by Schwarz (Casey, 1884).

Inopeplus praeustus Chevr.—Antilles. Adults and larvæ living gregariously in the burrows of a Scolytid in branches of cacao. The larva is peculiar in having the prolongations of the ninth abdominal segment in the form of forceps (de Peyerimhoff, 1903).

Family Scalidiidæ Bőving.

Catogenus rufus Fabr.—United States (Ind., Ia., Md., N. C., Fla.). Fiske (1905) has shown that the larva is an external parasite on the larvæ of Braconid Hymenoptera and Cerambycid pupæ; "its habits differing in no essential feature from those of many species of external Hymenopterous parasites. The adult is fairly common throughout the South, and is found beneath the loose bark of recently dead and dying trees, both conifers and deciduous. It occurs at nearly all seasons of the year, but is especially common during the late fall and early spring, and is found hibernating in situations similar to the above mentioned." Fiske seems to have overlooked a note on this beetle by Dimmock (1884), who says: "In Connecticut it is common beneath the loose bark of the trunks of hickory trees, and I have reared its larva which fed upon a pupa of *Elaphidion parallelum*, a borer in hickory."

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 6

(Tropical Research Station Contribution Number 100)

DESCRIPTIONS OF NEW SPECIES OF COLEOPTERA

By E. A. SCHWARZ and H. S. BARBER

United States Department of Agriculture

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

DECEMBER 24, 1921

DESCRIPTIONS OF NEW SPECIES OF COLEOPTERA

By E. A. Schwarz and H. S. Barber

United States Department of Agriculture

Specimens of three species of beetles from Kartabo, Bartica District, British Guiana, have been submitted to us by their discoverer, Dr. W. M. Wheeler, for identification. Two of the species belong to the family Silvanidæ, while the third is an inconspicuous species of the ubiquitous Coccinellid genus *Scymnus*. The two first are, however, very interesting forms, and it has been necessary to erect a new genus to receive the larger and more abundant species. These, Dr. Wheeler informs us, were occupying the petioles of a tree *(Tachigalia)*.

Coccidotrophus gen. nov. (Silvanidæ).

Eyes small, not emarginate, not prominent, occupying middle fourth of side of head. Antennæ inserted laterally, in deep cavity between frontal margin and prominent gena, close to and equidistant from base of mandible and front margin of eye; compactly eleven-jointed, club not abruptly enlarged, all joints traverse except basal joint; joints 3-9 rapidly increasing in size, the three-jointed club densely covered with fine short hairs. Antennal grooves short, distinct, parallel, bordered by lower edge of eye and carina from gena. Mouthparts free, maxillary palpi four-jointed, labial palpi three-jointed. Elytra with lateral costa and nine distinct series of strial punctures. Pygidium usually covered by elytra when abdomen is contracted (when distended the pygidium is often exposed). Intercoxal process of prosternum about one-seventh as wide as prothorax, wider behind, its sides overlapping the epimera; front coxae separated from hind margin of prothorax by about their own length. Intercoxal process of mesosternum slightly narrower than that of prosternum, truncate apically and nearly reaching hind margin of coxae, metepimeron reaching the middle coxae. Hind coxae separated by strong,

acute process of first abdominal sternite, which fits into median notch in metasternum. First ventral abdominal segment with coxal lines very fine, short, curved, becoming almost parallel behind, but not reaching posterior margin; four following sternites each slightly shorter than the first, the last rounded apically, concave beneath, with carinate posterior margin. Legs short, stout, femora incrassate, first three tarsal joints inflated, hairy beneath, fourth small but distinct, fifth joint as long as the three basal joints together. Genotype: *Coccidotrophus socialis* sp. nov.

This genus is so unlike other Silvanids known to us that its true affinity was not recognized until Dr. Böving's studies of its larva proved it to agree well with typical Silvanid larvæ and not to be related to *Hapalips*, with which we were trying to associate the adults. Once suggested this relationship was readily confirmed by the characters used by Ganglbauer (Die Käfer von Mitteleuropa, 1889, vol. 3, p. 577) to distinguish the adults of this family: front coxal cavities closed behind, metepimeron reaching middle coxae, etc.

We cannot identify *Coccidotrophus* with any of the genera considered by Grouvelle (Ann. Soc. Ent. Fr., vol. 81, 1912, pp. 313-386), but it seems most nearly to approach *Synoemis* Pascoe (1866), the only species of which was described from the Malayan Peninsula.

Coccidotrophus socialis sp. nov.

(Plate VI, figs. 1 to 5).

Very elongate, parallel, depressed, shining, castaneous, glabrous (except for sparse, microscropical, decumbent pubescence).

Length, 3.5-4.5; width, 0.6-0.8 mm.

Habitat—British Guiana.

Head slightly wider than prothorax, widest at the very slightly prominent eyes, one-sixth longer than wide, feebly constricted into a neck in basal fourth, sides convergent in front, front margin broadly, shallowly notched; upper surface finely granulose except a small occipital smooth area, feebly convex, transversely somewhat tumid between and behind eyes, which

are situated about middle of sides; clypeus not separated from front, produced into a strong marginal carina, surface convex medially, concave laterally, especially over antennal sockets; labrum very short, transverse, feebly chitinized, emarginate in front and with a row of about six stiff hairs; gular region strongly pilose, feebly concave; mandibles moderately prominent, strongly bidentate apically; antennæ stout, shorter than width of front at their point of insertion. Pronotum three-fourths as wide as long, widest at apical angles which are subacute; narrowest just before middle and at base; sides feebly sinuate, subparallel, front margin straight, hind angles obtuse, hind margin arcuate, surface longitudinally flat, transversely feebly convex, sparsely punctate, the punctures elongate, side margins with fine marginal line. Scutellum transverse, widest behind, finely punctate. Elytra slightly wider than pronotum, more than three times as long as wide, base emarginate, humeral angles subacute, sides subparallel to apical fourth, thence conjointly rounded; surface longitudinally somewhat convex, transversely rather strongly convex, strial punctures moderate, the interstices each with a series of slightly smaller punctures supporting fine, decumbent, short hairs. Under surface shining but with irregular microscopic sculpture between the sparsely scattered, nearly obsolete punctures which bear the short, fine decumbent hairs.

Described from thirty-two examples from a large series collected by Dr. Wm. M. Wheeler at Kartabo in July and August, 1920. The sexes are almost indistinguishable unless the "palps" of the ovipositor are extruded.

Characters of legs, antennæ and mouth are shown in accompanying figures. Type, allotype and paratypes.—Cat. No. 24070, U.S.N.M.

Eunausibius Grouvelle, 1912.

Although we have seen neither of the two species *(Nausibius tenebrionides* and *N. elongatus* Grouv.) upon which Grouvelle, (Ann. Soc. Ent. Fr., vol. 81, 1912, p. 314) established this genus, his generic diagnosis applies so well to the species here described that his genus is adopted. The postcoxal lines are very feeble and difficult to see but are bent abruptly forward to the coxal cavity enclosing a small area under the trochanter:

the antennal club seems to be more abrupt and larger, and the shape of the produced clypeus differs also from the figures Grouvelle, (Ann. Soc. Ent. Fr., vol. 65, 1896, p. 193) has given of the two previously known species.

Eunausibius wheeleri sp. nov.
(Plate VI, figs. 6 to 10).

Elongate, parallel, moderately convex, smooth, shining, glabrous, pale castaneous.

Length, 3.0-3.5 mm.; width, 0.6-0.75 mm.
Habitat.—British Guiana.

Head wider than prothorax; eyes rather large and prominent, coarsely granulated, front widest in front of the rather strongly impressed fovea opposite which the margin is somewhat thickened; front margin broadly, feebly emarginate, front angles obliquely truncate; surface finely granulate, feebly convex. Labrum membranous, concealed beneath front. Gular area feebly concave, opaque, finely pubescent, the lateral carinæ bordering the antennal grooves convergent posteriorly and passing middle of eye. Antennæ as long as width of clypeus, club abruptly widened, oval. Pronotum about three-fourths as wide as long, widest at the slightly acute front angles, sides almost straight and parallel, finely carinate; front margin straight except small sinuation near angles, hind margin arcuate at middle, on each side straight, hind angles obtuse. Surface transversely convex, longitudinally flat except for a pair of feeble impressions at basal fourth. Scutellum transversely oval, twice as wide as long. Elytra slightly wider than prothorax, three times as long as wide, sides parallel, apices evenly rounded; surface nearly smooth, strial punctures feebly impressed but conspicuous by coloration below surface. Callow specimens display interstrial rows of microscopic appressed hairs. Under surface of body sparsely clothed with microscopic decumbent hairs, each set in a broad obsolescent puncture.

Described from eighteen specimens submitted by Dr. Wheeler, to whom the species is dedicated. Two of the specimens, dissected and mounted on slides, are males. One specimen, the allotype, is somewhat crushed and displays female sex

organs. We are unable to distinguish the sex of the other fifteen paratypes.

Type, allotype and paratypes.—Cat. No. 24071, U. S. N. M.

The antennæ and legs are shown in accompanying figures.

Scymnus Kugelann 1794 (Coccinellidæ)

After some hesitation we have decided to offer the following description of what appears to be a new but very commonplace species of this genus, since we have failed to find any description applicable thereto. It will, perhaps, be long before the multitude of tropical species of *Scymnus* will be determinable.

Scymnus **(*Diomus*)** ***xantholeucus*** sp. nov.

Oval, very convex, shining, pubescent, pale yellow except basal two-thirds of elytra, meso- and metasternum and median third of first two abdominal segments, which are infuscate.

Length, 1.7 mm.; width, 1.2 mm.
Habitat.—British Guiana.

Head and pronotum finely, rather densely punctate, elytra slightly more coarsely punctured; pubescence rather dense, the short, silky, suberect hairs bent in all directions forming no pattern. Scutellum pale. Elytra piceous in basal two-thirds, apically flavescent, the pale area not sharply limited. Under surface moderately, densely and finely punctate, the pubescence decumbent and regular. Prosternum with carinae convergent anteriorly, reaching front margin and uniting in an arc; the enclosed area feebly concave and supporting moderately long hairs. Postmetacoxal line as in other species of *Diomus* (Group A of Horn 1895). Penultinate abdominal sternite very broadly and feebly emarginate in the male.

Type (male), allotype and paratypes.—Cat. No. 24084, U.S.N.M.

Described from two males and two females reared by Dr. Wheeler from larvae found among coccids in company with the two species of Silvanidæ.

Although not related to *semiruber* Casey, the foregoing species is similar in shape and plan of coloration. A prescutellar infuscate area is suggested in one example.

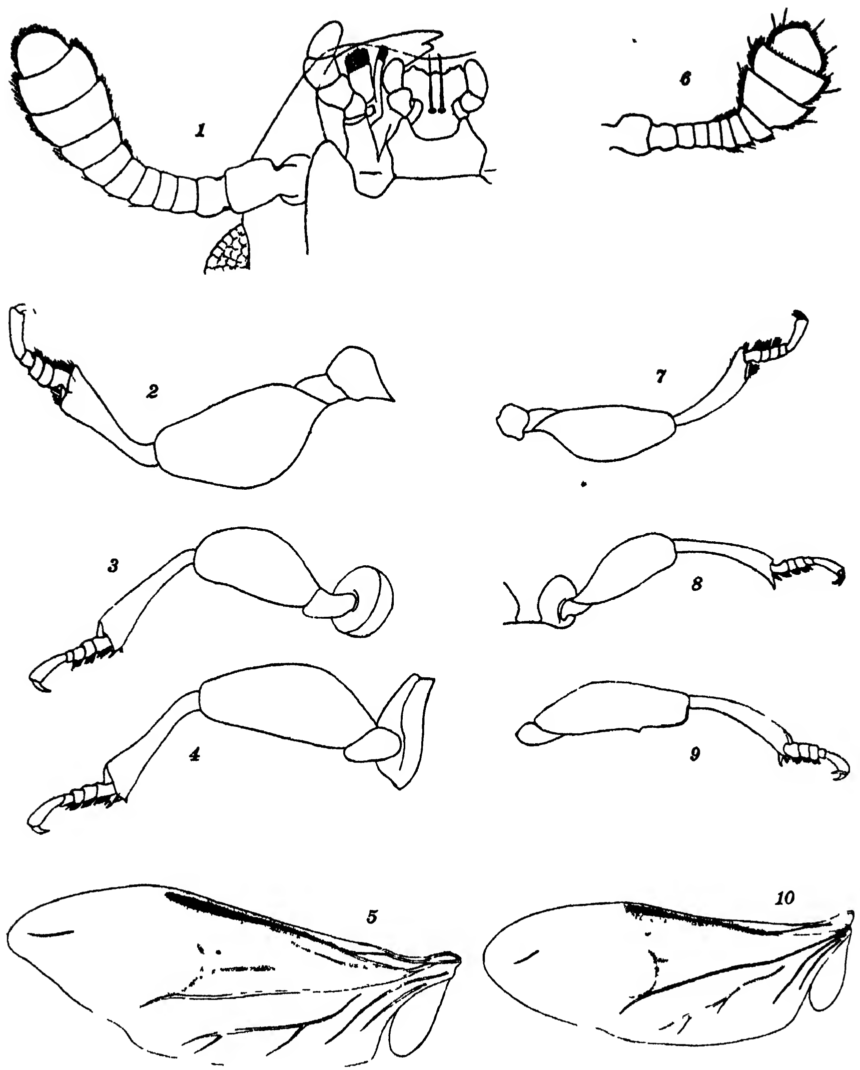


PLATE VI.

Fig. 1. *Coccidotrophus socialis* sp. nov. Right side of head, with antenna and mouth parts, ventral view. X 58.5.

Fig. 2. Fore leg of same. X 36.5.

Fig. 3. Middle leg of same. X 36.5.

Fig. 4. Hind leg of same. X 36.5.

Fig. 5. Hind wing of same. X 36.5.

Fig. 6. *Eunausibius wheeleri* sp. nov. Antenna. X 58.5.

Fig. 7. Fore leg of same. X 36.5.

Fig. 8. Middle leg of same. X 36.5.

Fig. 9. Hind leg of same. X 36.5.

Fig. 10. Hind wing of same. X 36.5.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 7

(Tropical Research Station Contribution Number 101)

THE LARVAE AND PUPAE OF THE SOCIAL BEETLES COCCIDOTROPHUS SOCIALIS (SCHWARZ AND BARBER) AND EUNAUSIBIUS WHEELERI (SCHWARZ AND BARBER) WITH REMARKS ON THE TAXONOMY OF THE FAMILY CUCUJIDAE

By Adam Giede Böving,. Ph.D.

Bureau of Entomology Department of Agriculture, Washington, D. C.

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

December 24, 1921

THE LARVAE AND PUPAE OF THE SOCIAL BEETLES COCCIDOTROPHUS SOCIALIS (SCHWARZ AND BARBER) AND EUNAUSIBIUS WHEELERI (SCHWARZ AND BARBER) WITH REMARKS ON THE TAXONOMY OF THE FAMILY CUCUJIDAE

By ADAM GIEDE BÖVING, PH.D.
Bureau of Entomology Department of Agriculture, Washington, D. C.

Professor W. M. Wheeler has kindly given me for study larvae and pupae of the two species of social beetles discovered by him in British Guiana. The material was plentiful and in excellent condition. In working out the relationship of these larvæ it was necessary to examine larvæ of several related groups and often to avail myself of studies as yet unpublished, undertaken by Dr. F. C. Craighead and myself on the classification of the Coleopterous families based on larval characters.

In addition to descriptions and illustrations of the two species, mentioned above, the present contribution therefore contains a brief discussion of the taxonomy of the entire family Cucujidae.

The different subjects are arranged as follows:

A. The family Cucujidae, *authorum;* taxonomic remarks with reference to their larvae.

B. The subfamily Silvaninae as based on larval characters.

- B. 1. Subfamily description of the larvae of the Silvaninae.
- B. 2. The genera of the Silvaninae, systematically defined by larval characters.

C. *Coccidotrophus socialis and Eunausibius wheeleri.*

- C. 1. General morphological description of the larvae.
- C. 2. Specific description of the larvae.
- C. 3. General and specific description of the pupae.

D. Bibliographical notes.

A.—The Family Cucujidae (*authorum*).

The larvae of *Coccidotrophus socialis* Schw. & Barb. and *Eunausibius wheeleri* Schw. & Barb. show remarkable identity in general morphological structures with the larvae of the genera *Oryzaephilus* Gangl., *Silvanus* Latr., *Nausibius* Redt. and *Cathartus* Reiche. All these forms differ from each other only in small details such as the proportional length of the second antennal joint, the arrangement of the individual ocelli in the two ocellar groups, the thickness and color of the chitin of the body or the number and development of the tergal setae. The larva of *Telephanus* (Plate X, figs. 34-38) has a well developed third antennal joint and differs in this and some other less important characters from the genera mentioned. However, it approaches them closely and constitutes together with them a well defined taxonomic unit distinct from the larvae of the rest of those genera which have generally been combined into the single family *Cucujidae*.

This family, however, as hitherto limited, mainly on adult characters, includes larval types which are rather heterogeneous; and according to these different larval types the family can be divided and I propose here to divide it, into several new families and subfamilies.

Thus it appears appropriate to establish the above mentioned unit of genera as a distinct family, the *Silvanidae*.

This family is, through the genus *Telephanus*, closely associated with another unit of genera, namely *Brontes* Fabr. and *Dendrophagus* Schön. (by Gilbert F. Arrow 1901 united into a single genus *Hyliota* Latr.), *Psammoecus* Latr., *Pediacus* Shuck, *Platisus* (according to description and figure by A. M. Lea of *P. integricollis* Reitter; Proc. Linn. Soc. N. S. Wales, vol. 29, 1904, p. 88) and *Cucujus* Fab., which together form a second family, the *Cucujidae* (in restricted sense) with *Brontes, Dendrophagus*, with *Psammocus* in one subfamily, the *Hyliotinae*, and the other genera in another subfamily, the *Cucujinae*. More remote is the relationship between these two families and the genera *Prostomis* Latr, and *Dryocora* (according to my own unpublished

notes and figures of four larvæ of *Dryocora howitti*, from New Zealand; in Zool. Mus. Cambridge, England), which two genera form a third unit and may constitute a subfamily, the *Prostominae* (Plate IX, figs. 22, 24-26 and 27-33). As a fourth unit I consider the genera *Prostominia* (according to the excellent description and figures by M. P. de Peyerimhoff of *P. convexiuscula* Grouv., Trans. Lin. Soc. London—2, Zool.—vol. 17, 1914, p. 156), *Narthecius* Lec., *Lathropus* Erichs., *Laemophloeus* Laporte, *Dysmerus* Csy., *Hemipeplus* Latr. and *Inopeplus* Smith (according to descriptions and figures by M. P. de Peyerimhoff of *P. praeustus* Chev.), (P. d. P. Ann. Soc. Ent. Fr., vol. 71, 1902-3, p. 715). According to an imperfect description by Weisse (Deutsch. Ent. Zeitsch., vol. 41, 1897, p. 393) of the larva of *Phloeostichus denticollis* Redtb., this genus also belongs to the present unit. All these larvae are closely related to the Prostominae, but separated from this subfamily by good characters; they may constitute another subfamily, the *Laemophloeinae* and together with the *Prostominae* the family *Laemophloeidae*. The Laemophloeidae are, as the following key will show, separated from the Silvanidae and Cucujidae (in restricted sense) by exactly the same main character by which such families as the Cryptophagidae are separated from the Mycetophagidae or the Monotomidae (represented by the larva of *Europs*) are separated from the Smicripidae (represented by the larva of *Smicrips palmicola* Lec.), namely the different shape of the maxillary mala. The genera *Catogenus* Westw. and *Scalidia* Er., constituting the family *Scalidiidae*, differ to such an extent from all the genera mentioned that their larvae must be placed in another series of families, the Cleroidea, proposed by myself in a recent paper (Adam G. Böving and A. B. Champlain, Larvae of North American beetles of the family Cleridae, Proc. U. S. Nat. Mus., vol. 57, pp. 588-95). They are, according to Dr. F. C. Craighead (Biology of Colydiidae and Bothrideridae, Proc. Ent. Soc. Wash., vol. 22, pp. 1-13, pl. I, II), closely connected with his new family, the Bothrideridae, and appear also to be near to the family Cleridae, having like this family protracted ventral mouthparts, large cardo region and elongate gula region (The figs. 39-44, Plate X, are reproduced from unpublished drawings by Dr. Craighead).

The four families with subfamilies, into which the old family Cucujidae may have to be divided according to larval characters, are characterized briefly in the following conspectus:

I. Mandible with molar structure and complicated hypopharyngeal chitinizations. Ventral mouthparts retracted; cardo in some forms indistinct, fused with enlarged margin of epicranium.

A. Maxillary mala (possibly lacinia) falciform, with terminal uncus; externally to uncus a more or less sharply defined, small setose region (possibly reduced galea). Maxillary articulating area distinct.

1. Without cerci. Eighth abdominal segment normally developed; ninth small, ventrally rudimentary; tenth long, extending far behind ninth segment; six ocelli........................Fam. *Silvanidae*

a. Antenna with second joint large and clavate, third joint very small, or wanting; ocelli in two distinct groups (Plate VIII, figs. 10, 12 and 18)..............................Subfam. *Silvaninae*

b. Antenna with three well developed joints; ocelli not in two distinct groups (Plate X, fig. 34..................................Subfam. *Telephaninae*

2. With cerci....................................Fam. *Cucujidae*

a. Tenth abdominal segment long, conical, extending far behind ninth abdominal segment................................Subfam. *Hyliotinae*

b. Tenth abdominal segment short, wartshaped, not extending behind ninth abdominal segment.................................Subfam. *Cucujinae*

B. Maxillary mala (possibly galea) obtuse, with or without well defined uncus, which when present is laterally placed on inside of mala (possibly terminating a reduced lacinia)........Fam. *Laemophloeidae*

a. Head larger than prothorax; without ocelli; maxillary articulating area present, cardo distinct; hypostoma normal (Plate IX, figs. 25, 33)........................Subfam. *Prostominae*

b. Head as large as or narrower than prothorax; with ocelli; usually having maxillary articulating area and cardo fused into a joint region, more or less amalgamated with broad enlargement of hypostoma,
Subfam. *Laemophloeinae*

II. Mandible without molar structure or hypopharyngeal chitinizations; ventral mouthparts protracted; gular region large (Plate X, figs. 41, 42)..........Fam. *Scalidiidae*

B.—The Subfamily Silvaninae.

B. 1.—Systematic Description of the Subfamily Silvaninae

Three pairs of legs. Fused tarsus and claw. Body orthosomatic, dorsally not plicate. Intersegmental membrane present. Ninth abdominal segment small, ventrally reduced. Cerci not developed. Tenth abdominal segment extending farther back than ninth, conical, elongate, a locomotory organ. Holopneustic; spiracles annular; first spiracle plainly mesothoracic. Head porrect and exserted, or slightly invaginated. Clypeus large, fused with frons. Labrum small, fleshy. Antenna two- (three-) jointed, with large clavate second joint, very small or indistinct apical joint. Mandible with flat, broad, molar part; accessory condyle present; retinaculum hamate; apex tri- (or quadri-) fid. Hypopharyngeal chitinizations strong, with paired, ovate, large maxillular area carrying longitudinal series of long setae. Ventral mouthparts retracted. Maxilla with cardo small, transverse, in some forms distinctly bidivided; stipes proximally and internally attached to large maxillary articulating area; mala extending from distal end of stipes, large, simple, falciform, terminated by single uncus; externally to base of uncus with small setose region, in some forms distinctly defined, being white and membranous in contrast to otherwise brown and well chitinized rest of mala. Maxillary palpus three-jointed. Labium

with broad ligula; without or with slightly indicated paraglossae; two jointed labial palp. Mentum—probably fused with submentum—large, barrelshaped, at base attached to maxillary articulating area, otherwise free. Gula large, hexagonal, transverse, interposed between postmaxillary margins of epicranium, the mental-submental area and the anterior prothoracic region.

Apart from the above mentioned, particularly close association with several genera of the old family Cucujidae, the Silvaninae also exhibit a pronounced relationship to the genera of the family Cryptophagidae, to the Monotomidae as represented by the larva of *Europs pallipennis* Lec. and to the genus *Languria,* which together with a few other genera, according to the larval structures, may constitute a distinct family. These larvae have all, like those of the Silvanidae and Cucujidae (restricted) a normally chitinized mandible (compare the Lathridiidae) and a simple and falciform maxillary mala; but they differ from the Silvanid and Cucujid larvae in having bifore spiracles.

B. 2.—The Genera of the Silvaninae Systematically Defined by Larval Characters.

The Silvaninae are represented in the collections of the U. S. National Museum by the larvae of *Carthartus advena* Waltl, *Nausibius clavicornis* Kugelann, *Silvanus quadricollis* Guérin, *Oryzaephilus surinamensis* Linnaeus, *Coccidotrophus socialis* Schwarz and Barber, and *Eunausibius wheeleri* Schwarz and Barber.

The genera which these larvae represent can be separated as follows:

1. Second antennal joint as long as head (Plate VIII, fig. 12) ....*Cathartus* Reiche
   Second antennal joint half as long as head or shorter 2

2. Second antennal joint half as long as head; upper ocellar group with four ocelli, lower group with two ocelli, or individual ocelli of each group confluent 3

Second antennal joint one-third as long as head; upper ocellar group with two ocelli, lower with four 5

3. Mandible apically quadrifid; individual ocelli in each group well separated; body well chitinized, with dark brown chitinous shields (Plate VIII, fig. 18), *Nausibius* Redt.

Mandible apically trifid; individual ocelli in each group almost confluent; body thinly chitinized, with pale yellowish shields....................................4

4. Maxillary palp with length of basal, second and apical joints as 1:1:2..................................*Silvanus* Latr.

Maxillary palp with length of basal, second and apical joints as 1:2:2.........................*Oryzaephilus* Gangl.

5. Dorsal shields of abdomen with one long seta on each side; body very thinly chitinized, creamy white (Plate VII, fig. 1), *Coccidotrophus* Schw. and Barb.

Dorsal shields of abdomen with two long and a few short setae on each side; body thinly chitinized, light grey (Plate VII, fig. 3), *Eunausibius* Grouvelle

C.—COCCIDOTROPHUS SOCIALIS AND EUNAUSIBIUS WHEELERI.

C 1.—General morphological description of the larvae.

(Plate VII, figs. 1-8, Plate VIII, figs. 9-11, 13, 16-17)

Orthosomatic with dorsal and ventral sides of body equally developed; thoracic segments not twice as long as seven anterior abdominal segments; lateral sides of body nearly parallel, tapering from eighth abdominal segment posteriorly. Legs ambulatory, of equal size, of medium length and strength; five-jointed, with tarsus and claw fused. Thoracic and abdominal terga not plicate, tergal areas forming shieldlike region. Segments smooth, without gills, thorns or thick pubescence, setae on both thoracic and abdominal segments. Ten abdominal segments

present; ninth small, ventrally reduced (*9* Plate VII, figs. 1 and 2), without cerci; tenth (*10* Plate VII, figs. 1 and 2) elongate conical, developed as a locomotory organ with extrusible, membranous anal lobes (*l* Plate VIII, fig. 2).

Head exserted beyond, or slightly retracted into anterior portion of prothorax; type of head porrect with frons horizontal and mouthparts stretched forward; form of head subtriangular with posterior part broader. Occipital foramen posterior, annular, dorsally limited by hind margin of epicranium, ventrally by hind margin of gular plate (*gu* Plate VII, fig. 7). No collum. Frons lyriform, one pair of oblong spots where frontal sutures anteriorly begin to diverge (Plate VIII, fig. 9). Frons and clypeus fused. Clypeus large, projecting to near tip of mandible, trapezoidal with sides converging forward, chitinized. Labrum short, soft and whitish, developed as a fleshy anterior margin of clypeus (Plate VIII, fig. 9). Epicranical halves dorsally entirely separated by frons; no median, epicranical suture; hypostoma (the epicranial margin between ventral articulation of mandible and attachment of posterior tip of cardo) (*hy* Plate VII, fig. 7) longitudinal with transverse curvation below cardo; epicranial margin longitudinally continued from tip of cardo to foramen occipitale. Gula median, unpaired, hexagonal, without paragular regions, chitinous, forming the ventral base of cranium between mentum (or probably fusion of mentum and submentum), the maxillary articulating area (*r* Plate VII, fig. 7), the epicranium and the presternal region of prothorax. Hypopharyngeal chitinization (*hpy. ch.* Plate VIII, fig. 16) (= lingua, Folsom), at entrance to pharynx, strong, triangular, considerably wider than long, with tuft of long setæ at each end; between tufts surface covered with numerous small, irregularly arranged rugosities. Coming from hypopharyngeal chitinization, creating firm support for same, is the following system of five pairs of chitinous rods: First pair (= lingual stalks, Folsom) (*1* Plate VII, fig. 8, Plate VIII, fig. 16) connecting hypopharyngeal chitinization with anterior corner of gular plate, perpendicular, parallel, imbedded in membrane between articulating area of maxilla and lateral side of base of mentum (or probably submental part of fused mentum—submentum). Second pair of rods (=hypoharyngeal

bracons, Hopkins) (*2* Plate VII, figs. 6, 8, Plate VIII, fig. 16) connecting hypopharyngeal chitinization with that region of epicranium which carries fossa for mandibular condyle; horizontal, transverse, imbedded in buccal membrane between mandible and dorsal side of maxillary stipes. Third pair of rods (*3* Plate VII, figs. 6, 8, Plate VIII, fig. 16) situated immediately in front of and parallel with anterior margin of hypopharyngeal chitinization; horizontal, converging anteriorly, meeting in middle line. Fourth pair (*4* Plate VII, figs. 6, 8, Plate VIII, fig. 16) supporting and externally limiting the maxillular areas, vanishing distally near glossa (= buccal surface of ligula) (*glos.* Fig. 16); horizontal, longitudinal and parallel. Fifth pair (*5* Plate VII, figs. 6, 8, Plate VIII, fig. 16) forming a posterior prolongation of fourth pair of rods, imbedded in sides of oesophagus; horizontal, longitudinal and parallel; proximally, near hypopharyngeal chitinization, with fossa for accessory mandibular condyle (*fos. a. c. m.* Plate VIII, fig. 16), distally gradually vanishing.* Maxillular areas (*sensu* H. T. Hansen, = superlingua Folsom) (*mxl* Plate VIII, fig. 16) fleshy, ovate, anteriorly fused together, posteriorly well separated, limited externally by fourth and internally by third pair of rods; along third pair with a series of well developed, closely set setæ. Glossa (= buccal surface of ligula-lingua, Schiődte) (*glos.* Plate VIII, fig. 16) unpaired, fleshy, in front of maxillular area, laterally supported and limited by a pair of longitudinal, horizontal, chitinous rods (*stp. li.* Plate VIII, fig. 16); similar to the fourth hypopharyngeal pair. Epipharynx (Plate VIII, fig. 11) consisting of anterior and posterior part. Anterior part a direct ventral continuation of labrum; soft, membranous, medially on the hind margin with a small triangular asperity, which fits in between the scissorial parts of the closed mandibles; well developed tendons (*t* Plate VIII, fig. 11) extending from each back-corner; some long setæ. Posterior part of epipharynx slightly chitinized, with several transverse, long, curved, parallel wrinkles. Tentorium an internal cranial structure, differing in that respect from the two mentioned systems of chitinizations in

* The pair of rods is not present which in many other Coleopterous larvae extends from proximal ends of fifth pair, along sides of epipharynx, towards end of large movable labrum.

the buccal membrane above labium and above the mental-submental area; consisting of a median broad and short, slightly chitinized, transverse tentorial bridge (*ten. b.* Plate VII, fig. 7), situated a short distance above gular plate and of two pairs of tentorial arms; the first pair of arms lateral (*t. l. a.* Plate VII, fig. 7), between bridge and tentorial pits (*tp.* Plate VII, fig. 7) where gular plate and epicranium meet; the second pair anterior (*t. a. a.* Plate VII, fig. 7), reaching from tentorial bridge toward the dorsal side of cranium, their external ends distally indistinct. Ocelli (Plate VIII, fig. 10) six, placed in two groups, a lower behind mandible and an upper straight behind antenna and right above first group. Antenna with large basal membrane, two- (three-) jointed; basal joint (*1* Plate VII, fig. 5) short, second joint (*2* Plate VII, fig. 5) long, claviform, with tip (*3* Plate VII, fig. 5) more or less distinctly separated as a small additional joint. Mandible (Plate VII, figs. 4 and 5) with molar part, retinaculum and accessory ventral condyle; half as long as head; apical part (*p. sc.* Plate VII, fig. 5) distinctly constricted, incurved, vertically compressed, fornicate, cleft with some toothlike ends; rest of mandible horizontally flat, subtriangular with wide base; retinaculum present (*r* Plate VII, fig. 5), hamate, short, pointed, with enlarged socket; molar part broad (*m.* Plate VII, fig. 5, Plate VIII, fig. 17), compressed, with dorsal surface smooth, ventral surface roughened by numerous granules, these being anteriorly rather large and irregularly distributed, posteriorly minute and densely placed in longitudinal rows; basal molar fringed with a series of anomalous, chitinous, stiff, filamentous processes (*fil. pr.* Plate VIII, fig. 17), which gradually diminish in length from inner corner of basis toward accessory condyle; accessory condyle (*acces.* Plate VIII, fig. 17), as mentioned above, fitting into groove (*fos. a. c. m.* Plate VIII, fig. 16) in fifth hypopharyngeal rod.* Ventral mouthparts

* This articulation between the mandibles and the whole system of amalgamated chitinous hypopharyngeal and epipharyngeal structures indicates that the side to side movements of the mandibles caused by extensor-flexor—(= abductor-adductor)—muscles, always must be coincident with the forward-backward movements of the following closely united structures: the anterior portion of oesophagus, the hypopharynx with other buccal structures, and the ventral mouthparts, and also coincident, when a free, well-developed labrum and movable clypeus are present, with their up and down nodding motions. All forward and upward directed movements are caused by blood pressure combined with special arrangements of the articulations; all backward and downward directed movements by retractor muscles.

retracted with tip of cardo articulating at considerable distance behind the ventral condyle of the mandible (*vc.* Plate VII, fig. 7); hypostomal curvation adjacent to both stipes and cardo. Maxillary articulating area large, membranous, placed between stipes, maxillae, cardo, gular plate and posterior part of the mental-submental region. Cardo maxillaris approximately transverse, bidivided, much narrower than long, tip articulating with hypostoma at distinct distance from occipital foramen. Stipes maxillaris connected with the articulating area along the proximal two-thirds of its inner margin; distal part free. Mala (=maxillary lobe) (*lac* Plate VIII, fig. 16) simple, projecting as a direct anterior continuation of stipes, apically attenuate, terminating with a single, well developed uncus (*u* Plate VIII, fig. 16); external apical part of mala (*gal* Plate VIII, fig. 16) soft-skinned with some strong, straight setae behind uncus:* inner margin of mala set with strong setae. Palpiger maxillaris (*plg. mx.* Plate VIII, fig. 16) well developed, subtriangular. Maxillary palp well developed, three-jointed. Submentum probably fused with mentum, forming together a barrelshaped, free unit (*m* Plate VII, fig. 7). Labium (proper) posteriorly limited by a chitinous bow, extending between the ends of those rods which laterally support and limit the glossa; palpiger labii not distinctly chitinized. Ligula (*lig* Plate VII, fig. 7) broad.** Labial palp short, two-jointed. Between head and prothorax there is a well developed cervical membrane, capable of being invaginated into and protruded from the anterior part of prothorax. Thoracic segments similar in size and development. Prothoracic presterna (*prst 1* Plate VII, fig. 7) large broad, oval,

---

* Possibly corresponding to galea, while chitinized rest of mala is lacinia (*lac* Plate VIII, fig. 16).

** The term "ligula" (= glossa, Folsom) is here applied to the median, terminal labial lobe, which is composed of the fused right and left labial malae. For descriptive purposes it appears practical to use special terms for the ventral and buccal surfaces of this lobe; the term "ligula" is here applied only to the ventral surface (*lig* Plate VII, fig. 7), while the buccal surface is mentioned as "glossa" (*glos.* Plate VIII, fig. 16). The structure which Schiödte calls "ligula" is not identical with the entire labial lobe in question, as he designates as the ligula only a special, jointed, terminal part of the lobe; the rest, or, when no jointed terminal part is developed, the entire lobe Schiödte calls "lingua," and he applies this term both to the ventral and buccal surfaces.

adjacent to a medium, simple, elongate, suboval eusternal sclerite (*eu* Plate VII, fig. 7); furcal pits (*fur* Plate VII, fig. 7) near inside of legs. A well developed triangular poststernellum (*pstl* Plate VII, fig. 7) present. Between pro- and mesothorax and between meso- and metathorax a well developed intersternal ring consisting of the poststernellar area (*pstl.* Plate VII, fig. 7) of the anterior and the presternellar areas (*prst* Plate VII, fig. 7) of the posterior or two connected segments. Presternal areas of meso- and methathorax, subtriangular, dorsally only slightly separated from the spiracle-bearing preëpipleural areas of the segments. Hypopleural areas, above coxae, separated by a distinct, short, perpendicular, chitinous line extending from coxal hinge into an anterior subdivision, prehypopleurum (=episternum *authorum*), and a posterior one, posthypopleurum (=epimeron *authorum*). Legs inserted widely apart (*leg* Plate VII, fig. 7). Abdominal segments, from first to eighth, differing only slightly in size and shape, about as wide as thoracic segments, somewhat shorter. Intersegmental membranes, indistinctly developed dorsally and laterally, more distinctly ventrally. Each abdominal segment with tergal areas fused, with poorly defined, low epipleural area without lobe or other subdivisions, with hypopleurum large, somewhat bulging, dorsally clearly limited by a ventro-lateral suture, ventrally less sharply defined; sternal areas more or less fused. Ninth and tenth abdominal segments mentioned above (p. 204). Spiracles annular (Plate VII, fig. 2, Plate VIII, fig. 13), not very conspicuous; mesothoracic twice as large as abdominal; metathoracic rudimentary; both meso- and metathoracic spiracles—as already mentioned—located in preëpipleurum; abdominal spiracles all lateral and of same size, located in the tergal regions medially or posteriorly near the rather indistinct dorsolateral suture. One pair of small chitinous spots present dorsally on the thoracic segments; one pair dorsally and one pair ventrally on most of the abdominal segments. Rounded, soft organs, shaped like cloverheads attach internally to these spots; function unknown.

C. 2.—Specific Description of Larvae of Coccidotrophus socialis and Eunausibius wheeleri.

Coccidotrophus socialis Schwarz and Barber

(Described from specimens preserved in U. S. National Museum.)

(Plate VII, figs. 1 and 2.)

Mature Larva:

Length about 4 mm. Width of prothorax about 1 mm. Whitish, very thinly chitinized. Head with width to length as 1:1½. Length of head and thorax, together in proportion to abdomen as 3:5. Ocelli four in a lower, square group, two in an upper group. Frons with short setae sparsely scattered over the surface; the paired spots at frontal sutures yellow. Clypeal region anteriorly with transverse series of four long setae, laterally with one long seta on each side, several short setae scattered over entire surface. Labrum, with several very short setae. Another part of epipharynx with four long setae along the front margin and one long seta on each side near the attachment of the epipharyngeal tendon; posterior part of epipharynx without setae. Hypostoma about half as long as lateral outline of epicranium. Epicranial postmaxillary margin about half as long as cardo. Epicranium, with a few long and some short setae scattered over the surface. Antenna about half as long as head from front margin or labrum to occipital foramen; basal antennal joint about half as long as second joint (soft-skinned apical part excluded), subcylindrical, twice as long as wide; second antennal joint clubshaped, with end twice as wide as base, almost one-third as long as length of head; tip of antenna membranous, whitish, low, rounded, not distinctly set off from second joint; no supplementary appendix; a ring of densely set spinules present on distal end of basal joint, numerous thin and medium long or short setae irregularly scattered over the whole surface of second joint. Mandible with apical part trifid, several setae of different sizes on exterior lateral mandibular region. Each maxillular area ovate, membranous; individual setae belonging to series along inner margin of medium size, somewhat curved, bending outward. Maxilla, with end of cardo articulating at a distance from occipital foramen,

somewhat more than half the length of cardo; free distal part of stipes dorsally with one long seta; mala with inner margin set with two parallel series of strong, somewhat curved setae; palpiger maxillaris with a few minute setae; maxillary palp well developed, surpassing tip of mala by one-half the length of the apical joint, with basal joint cylindrical, somewhat wider than long; second joint cylindrical, as wide as long; apical joint slightly conical, almost as long as the two other joints together, half as wide; front margin of two posterior joints with minute spines in a ring; apical joint with one long seta and terminally with several sensory papillæ. Submentum with two pairs of setae. Ligula anteriorly rounded, with several rather short setae; no paraglossae. Labial palp about as long and wide as the apical joint of the maxillary palp; basal joint about two-thirds of the entire length of labial palp; apical joint anteriorly obtusely rounded and provided with many minute sensorial projections. Thoracic segments almost equally developed, each about as wide and long as head; weak line present between furcal pits, separating an anterior eusternal region from a posterior sternellar region; poststernellar areas of pro- and mesothorax well developed, marked with a median chitinous spot. Prothorax with eusternal sclerite as wide and somewhat longer than each prothoracic presternum. Thoracic tergal shields with one seta on each side, the prothoracic rather short; meso- and metathorax with one yellow spot anteriorly to the seta. Legs with coxa about as long as clypeal region, slightly longer than thick; trochanter half as long as coxa; femur and tibia of equal size, slender, each slightly longer than second antennal joint, about four times as long as thick; clawshaped tarsus not quite as long as basal antennal joint. Eight anterior abdominal segments with tergal shields carrying along the hind margin a series of seven to eight setae on each side of middle line; one seta, externally placed, very long, the others very small; scattered all over the whole surface of shield, numerous, extremely minute setae. In front of long seta with yellow, chitinous spot. Spiracles posteriorly placed, below the shields. Epipleurum narrow, without seta. Hypopleurum with large median lobe and one long seta; sternal areas on each side with two long setae and one yellow chitinous spot. Ninth abdominal segment only represented by small tergal part, about as large

as hypopleurum of eighth abdominal segment, with one small seta and some very minute scattered over whole surface. Tenth abdominal segment as long as one of the well developed abdominal segments, conical, one and one-half times as long as wide; a ring of small setae right above the truncate end; also with very minute setae scattered over whole surface. Mesothoracic spiracle about as large as base of claw, situated on top of small softskinned conical tube; abdominal spiracles half as large and not on tubes.

Newly hatched larva:

Length 1 mm. Width of prothorax 0.25 mm. Length of head and thorax together about as long as abdomen. One very long seta on each side of hind margin of tergum; setae corresponding to the small setae along hindmargin comparatively longer than those of mature larva; no setae corresponding to minute setae on the whole tergal surface.

Eunausibius wheeleri Schwarz and Barber.
(Described from specimens preserved in U. S. National Museum.)

Mature Larva:

Length, about 3.5 mm. Width of prothorax, about 0.75 mm. Length of head and thorax combined, in proportion to length of abdomen, about as 3:5. Shields thinly chitinized, light grey, shiny. Both thoracic and abdominal segments along hindmargin with a series of six to seven setae on each side; two sets very long, the others short; rest of tergal shield smooth with a few very minute setae. Abdominal hypopleurum with one long and one short seta. Otherwise like *Coccidotrophus socialis,* to which larva it is very closely related.

C 3.—General and specific description of the Pupae of Coccidotrophus socialis and Eunausibius wheeleri.
(Plate IX, figs. 19-21, 23)

General Description.

Body somewhat depressed; about five times as long as width of prothorax. Head large and wide; not to be seen from above;

with four or five very minute spinules on dorsal surface. Prothorax flat, subrectangular; with length to width at 1.25:1.00; anterior third slightly broader than rest; anterior corner somewhat rounded; posterior corner rectangular; with one setiferous protuberance at each anterior corner and a few along the sides, otherwise entirely smooth. Meso- and metathorax smooth. Abdomen with third segment the widest and as wide as prothorax; first and second abdominal segments slightly narrower; posterior segments gradually decreasing to the seventh, which anteriorly is half as wide as the third and posteriorly only two-thirds as wide as anteriorly; eighth to ninth abdominal segments small, forming together a rounded almost semicircular termination of body. Second to seventh abdominal segments laterally with small protuberances, without setae; ninth abdominal segment dorsally terminating with two small, slender, cylindrical, divergent cerci. Spiracles annuliform, located on meso- and metathorax and on the first to eighth abdominal segments, where lateral protuberances develop spiracles placed immediately above and in front of these. Pouch covering elytron extending to posterior margin of fourth abdominal segment, smooth, with four well marked longitudinal ribs. Tarsal cover of hind legs ventrally extending to middle of fourth abdominal segment; the entire leg-pouch smooth. Antennal pouch short, clubshaped, directed backward and outward; ends of the last three or four joints marked by a ring of small projections.

Specific Characterization.

Coccidotrophus socialis Schwarz and Barber.

(Pupa described from specimens preserved in the U. S. National Museum).

(Plate IX, figs. 19-21)

Length, about 4 mm. White. Prothorax with anterior lateral protuberance small, but distinct, three posterior lateral protuberances much reduced, not to be seen with naked eye or ordinary lens magnification.

Eunausibius wheeleri Schwarz and Barber
(Pupa described from specimens preserved in the U. S. National Museum)
(Plate IX, fig. 23)

Length, 3-4 mm. Grey. Prothorax with five lateral protuberances well developed, to be seen with naked eye or ordinary lens. (On specimen figured one protuberance was—abnormally—not developed on left side.)

D.—Bibliographical Notes.

A careful list of the descriptions and figures of the larvae of the family Cucujidae (*auth.*), including reference to P. de Peyerimhoff's key for the determination of the larvae of the Cucujid genera, is given by F. H. Gravely (in Records of the Indian Museum, Calcutta, vol. II, 1915, pp. 353-358).

To this list might be added the part dealing with this family in L. Ganglbauer: Die Käfer von Mitteleuropa, vol. III, part 2, 1899. Since the list of Gravely was published an important work has appeared by U. Saalas: Die Fichtenkäfer Finnlands (in Annales Academiae Scientiarum Fennicae Ser. A, vol. VIII, 1917 pp. 508-528, figs. 119-130). In Saalas' book are described and splendidly figured with habitus and detail drawings the following larvae (and pupae): *Pediacus fuscus* Er., *Laemophloeus abietis* Wank, *Laemophloeus alternans* Er.

Finally I may mention that the larva described and figured by C. V. Gernet as "Cucujiden-Larve" (*Dendrophagus crenatus* Payk) is in my opinion a *Staphylinid* larva of the group Aleocharini. The figure shows the combination of a mandible without mola and jointed cerci, movable at base, which is characteristic of the Staphylinids; and also a large movable labrum, a single ocellus and broad ligula, which characters define the Aleocharini.

The newest taxonomic arrangement of the Cucujidae is presented by Charles W. Leng in: "Catalogue of the Coleoptera of America, North of Mexico," Mount Vernon, N. Y., John D. Sherman, 1920. The arrangement of the larvae given in the present paper does not agree so well with Mr. Leng's list as with the system presented in 1899 in L. Ganglbauer's "Käfer von Mitteleuropa."

Plate VII.

(Figures drawn by A. G. Böving).

Fig. 1. *Coccidotrophus socialis.* Dorsal view of larva.

Fig. 2. *Coccidotrophus socialis.* Side view of larva.

Fig. 3. *Eunausibius wheeleri.* Dorsal view of larva.

Fig. 4. *Coccidotrophus socialis.* Right mandible from above.

Fig. 5. *Coccidotrophus socialis.* Right mandible from below. *ac,* accessory condyle; *f,* chitinous appendices from base of mola; *flx,* tendon of flexor mandibulæ; *m,* mola; *psc,* pars scissoria; *r,* retinaculum; *v,* ventral condyle of mandible; *1-2-3,* first-second-rudimentary third antennal joints.

Fig. 6. *Coccidotrophus socialis.* Hypopharyngeal rods in buccal membrane. Dorsal surface of ventral mouthparts. *1-2-3-4-5,* see explanation of Fig. 16, Plate VIII.

Fig. 7. *Coccidotrophus socialis.* Head, Prothorax and Mesothorax from below. *a1-a2,* first and second antennal joints; *b,* bracon (= second hypopharyngeal rod); *bm,* basal membrane of antenna; *est,* eusternum; *eu,* eusternal plate of prothorax; *fur,* pit indicating attachment of furca; *gu,* gula; *leg,* basis of leg; *lig.* ligula; *m,* mentum and submentum fused; *prst, 1, 2* and *3,* presternum; *pstl 1* and *2,* poststernellum of first and second thoracic segments; *r, sp.,* rudimentary spiracle of metathorax; *sp,* spiracle of mesothorax, *stl,* sternellum; *taa,* anterior arm of tentorium; *tenb,* bridge of tentorium; *tla,* lateral arm of tentorium; *tp,* tentorial pit, longitudinal groove, indicating attachment of lateral arm of tentorium; *stl,* sternellum; *vc,* mandibular fossa of epicranium.

Fig. 8. *Coccidotrophus socialis.* Ventral surface of ventral mouthparts. *1-2-3-4-5,* five hypopharyngeal rods, see explanation of Fig. 16, Plate VIII.

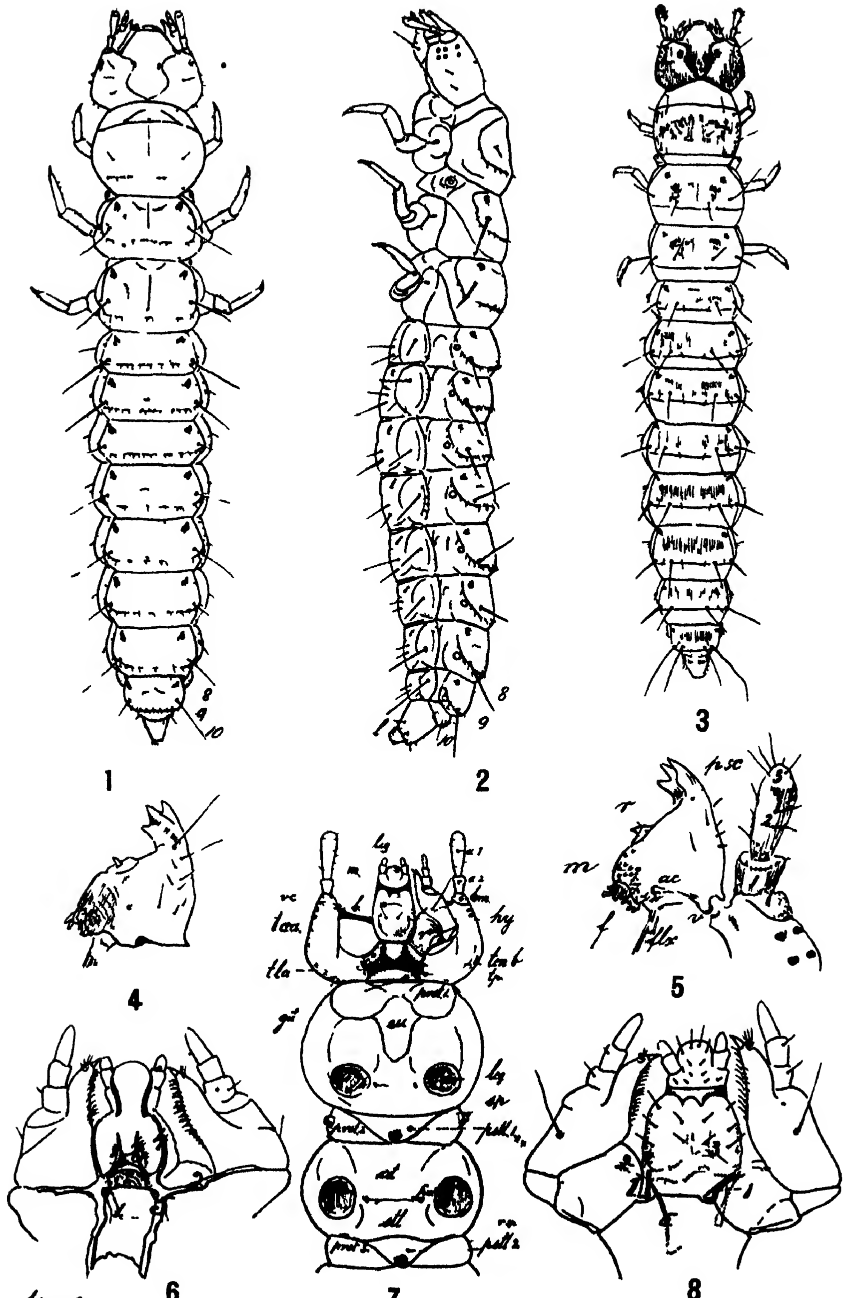


Plate VII

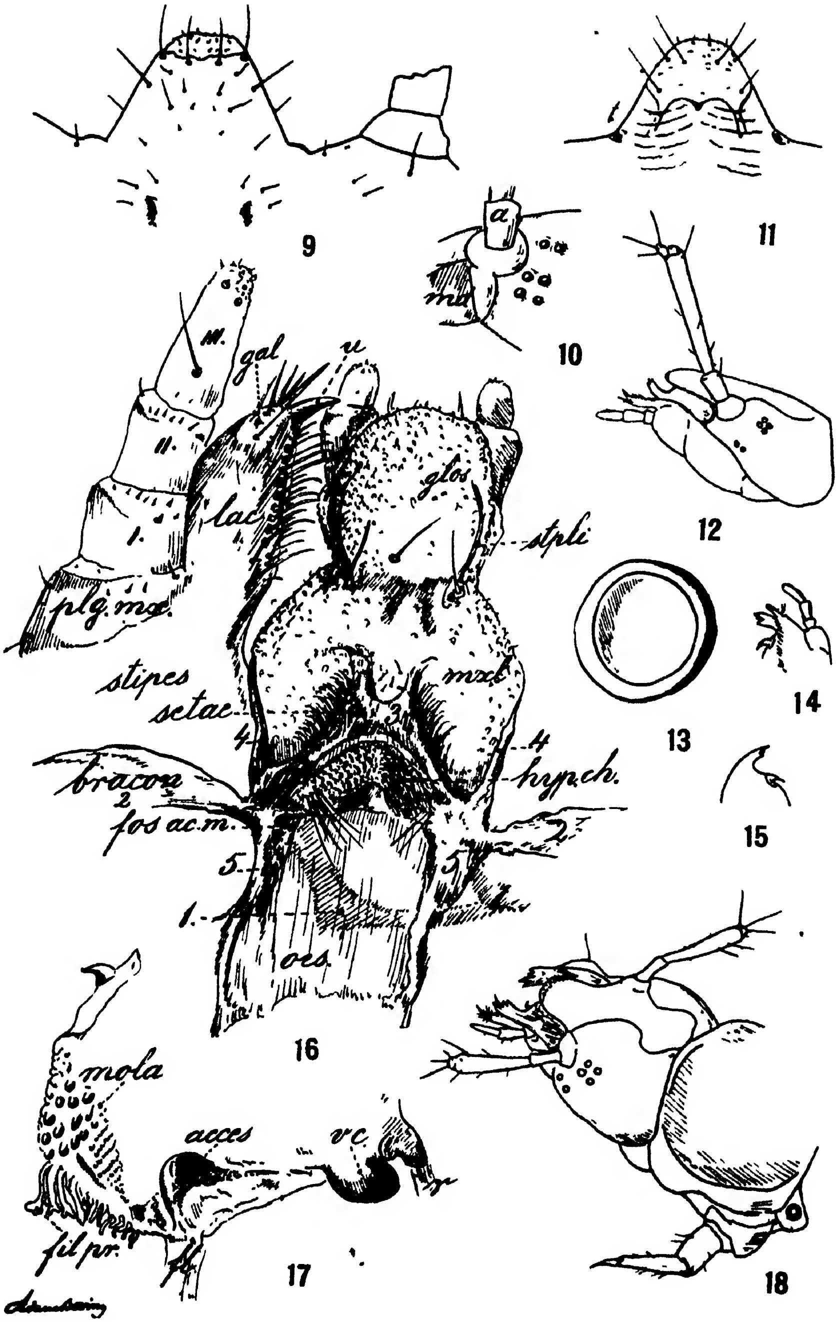

9
a
mx
10
11
12
13
14
15
m.
gal
u
ii.
i.
lac
glos
stpli
plg.mx
stipes
setae
mx
4
4
3
hyp.ch.
bracon
2
fos.ac.m.
5
5
1.
oes
16
mola
acces
vc
fil.pr.
17
18

Plate VIII

Plate VIII.

(Figures drawn by A. G. Böving).

Fig. 9. *Coccidotrophus socialis.* Anterior part of head from above, showing frons with chitinous spots, clypeus fused with front, membranous short labrum, basis of antenna.

Fig. 10. *Coccidotrophus socialis.* Anterior part of head from right side, showing basis of antenna basis of mandible, upper group of two ocelli, lower group of four ocelli.

Fig. 11. *Coccidotrophus socialis.* Epipharynx.

Fig. 12. *Cathartus advena.* Head from left side.

Fig. 13. *Coccidotrophus socialis.* Spiracle, highly magnified.

Fig. 14. *Cathartus advena.* Anterior part of left mandible and maxilla from below.

Fig. 15. *Cathartus advena.* Anterior part of left mandible from above.

Fig. 16. *Coccidotrophus socialis.* Maxilla, hypopharynx, maxillular area and glossa (= dorsal surface of ligula) facing buccal cavity; bracon, second chitinous rod from hypopharyngeal chitinization; *fos. ac. m,* fossa for the accessory mandibular condyle in base of hypopharyngeal chitinization (*acces,* fig. 17, Plate VIII); *gal,* possibly rudimentary galea; *glos,* glossa; *hyp. ch,* hypopharyngeal chitinization; *lac,* lacinia; *mxl,* maxillular area; *oes,* oesophagus; *plg. mx,* palpiger maxillæ; *u,* uncus; *setae,* setae along chitinous rod number three; *stipes,* dorsal surface of stipes maxillæ; *stpli,* chitinous rod between glossa and palpiger labii; *1-2-3-4-5,* chitinous rods from hypopharyngeal chitinization; *I-II-III,* basal, second, apical joints of palpus maxillaris.

Fig. 17. *Coccidotrophus socialis.* Posterior part of left mandible from below; *acces,* accessory condyle fitting into fossa in base of hypopharyngeal chitinization (*fos. ac. m,* fig. 16, Plate VIII); *fil, pr,* stiff chitinous filaments; *fl,* tendon of flexor mandibulæ; *mola,* granular ventral surface of the molar structure; *r,* tendon of retractor mandibulæ; *vc,* ventral condyle of mandible fitting into fossa of epicranium (*vc,* fig. 7, Plate VII).

Fig. 18. *Nausibius repanda.* Head and anterior part of thorax.

Plate IX.

(Figures drawn by A. G. Böving).

Fig. 19. *Coccidotrophus socialis.* Pupa; left side.
Fig. 20. *Coccidotrophus socialis.* Pupa; dorsal side.
Fig. 21. *Coccidotrophus socialis.* Pupa; ventral side.
Fig. 22. *Prostomis mandibularis.* (Denmark, Europe), Maxilla; *mx. art. a.*, maxillary articulating area.
Fig. 23. *Eunausibius wheeleri.* Pupa; left side. (Specimen slightly abnormal, having only four lateral projections on left side).
Fig. 24. *Prostomis mandibularis.* Larva from above.
Fig. 25. *Prostomis mandibularis.* Head from below.
Fig. 26. *Prostomis mandibularis.* Terminal part of abdomen from below.
Fig. 27. *Dryocora howitti* (New Zealand). Maxilla.
Fig. 28. *Dryocora howitti.* Mandible.
Fig. 29. *Dryocora howitti.* Ninth abdominal segment from above.
Fig. 30. *Dryocora howitti.* Ninth abdominal segment, left side
Fig. 31. *Dryocora howitti.* Head; dorsal side.
Fig. 32. *Dryocora howitti.* Larva from above.
Fig. 33. *Dryocora howitti.* Head; ventral side.

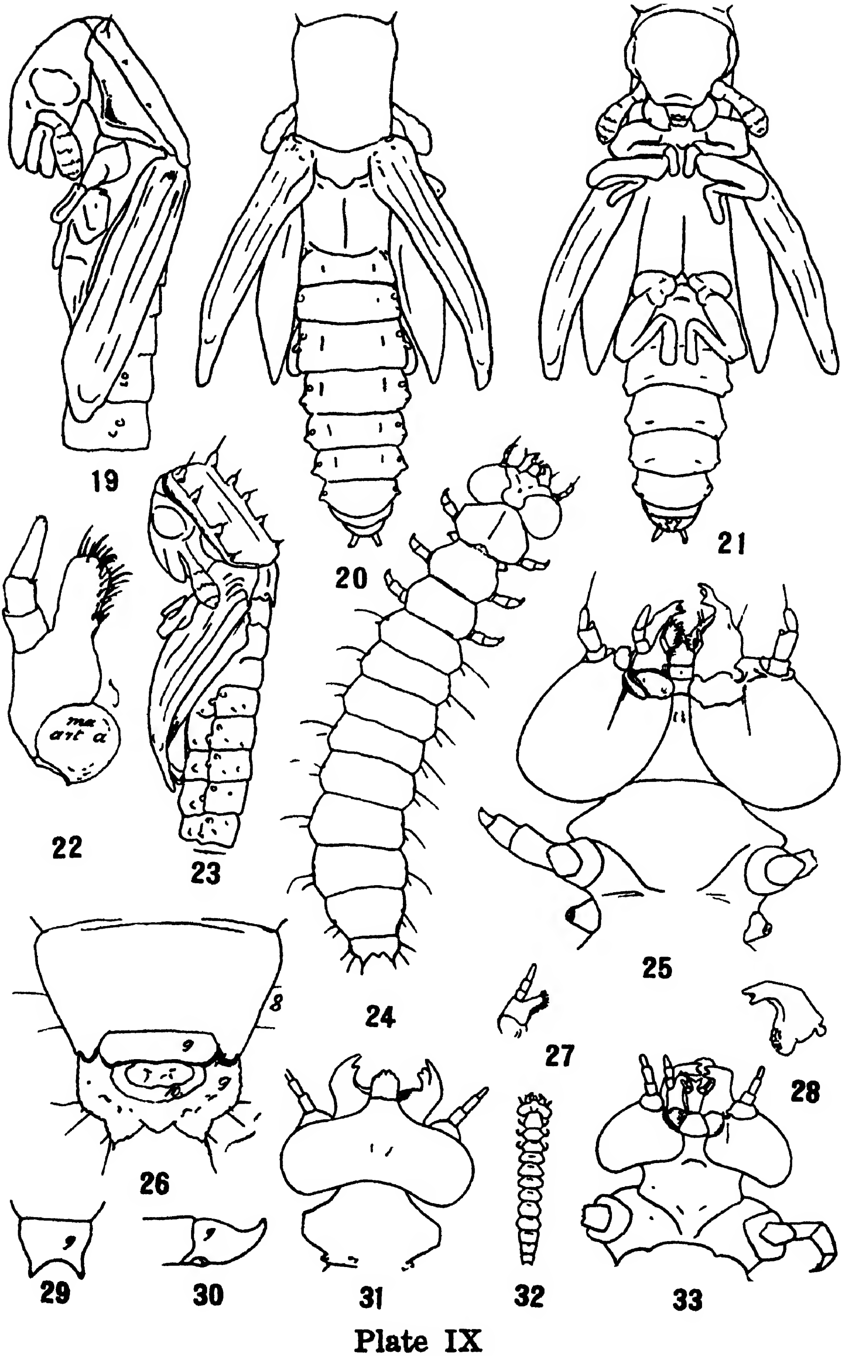
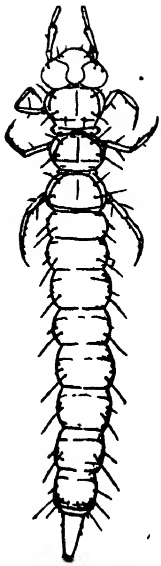
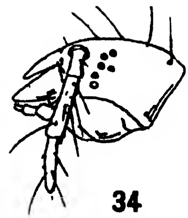


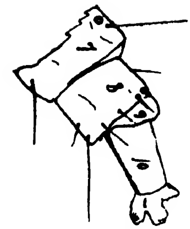
Plate IX



37



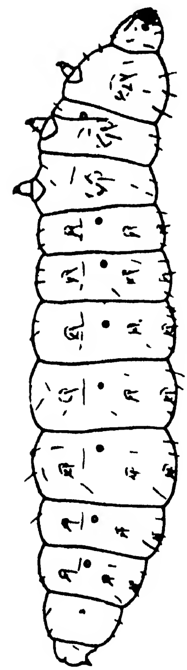
34



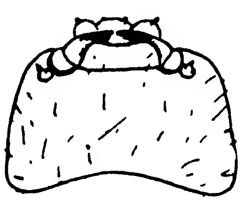
35

36

38



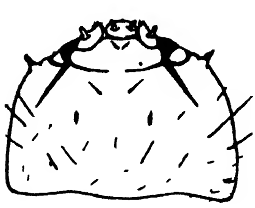
44



39

40

41



42

43

Adam Böving F. C. Craighead

Plate X

Plate X.

(Figures 34-38 drawn by A. G. Böving).
(Figures 39-44 drawn by F. C. Craighead).

Fig. 34. *Telephanus pallidulus* (Rio Piedras, Porto Rica). Head; left side.

Fig. 35. *Telephanus pallidulus*. End of abdomen; left side.

Fig. 36. *Telephonus pallidulus*. Left mandible; ventral surface.

Fig. 37. *Telephanus pallidulus*. Mature larva; dorsal side.

Fig. 38. *Telephanus pallidulus*. Maxillæ, glossa, maxillular area, hypopharyngeal chitinization, oesophagus; facing buccal cavity.

Fig. 39. *Scalidia linearis* Lec. Head; dorsal side. (Note: No distinct clypeus, large movable labrum).

Fig. 40. *Scalidia linearis*. Leg.

Fig. 41. *Scalidia linearis*. Right mandible; dorsal surface. (Note: No molar structure).

Fig. 42. *Scalidia linearis*. Head; ventral surface. (Note: Protracted mouthparts; large region formed by fusion of cardines, mentum and submentum; also large region formed by fusian of epicranial halves and gula).

Fig. 43. *Scalidia linearis*. Spiracle;. annuliforme.

Fig. 44. *Scalidia linearis*. Left side of the mature, parasitic larva.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 8

(Tropical Research Station Contribution Number 102)

A NEW DIADIPLOSIS

By E. P. Felt

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

December 24, 1921

A NEW DIADIPLOSIS

By E. P. Felt

The midge described below was received from Prof. Wheeler accompanied by the statement that the larvae were devouring mealy-bugs (*Pseudococcus bromeliae* Bouché) in a cavity of a peculiar myrmecophilous tree, *Tachigalia*, in British Guiana. The coccids and the fly larvæ live in a cavity of the leaf petiole.

This species approaches closely that West Indian *Diadiplosis cocci* Felt, which was reared from larvæ preying upon the eggs of *Saissetia nigra* Nietn., a scale insect frequently abundant upon the stems of Sea Island cotton. The female of the West Indian species has a distinct knob upon the terminal antennal segment and the lobes of the oviposter are somewhat narrower, two characters which serve to distinguish the species, though it is frequently very difficult to find characteristic structures in female gall midges.

Diadiplosis pseudococci sp. nov.

Female. Length 1.25 mm. Antennae extending to the base of the abdomen, sparsely haired, yellowish brown, of fourteen segments, the fifth with a stem about one-fourth the length of the cylindrical basal enlargement, which latter has a length about two and one-half times its diameter and is slightly constricted near the basal third; low, broad circumfila occur on the enlargement at the basal third and apically; basally there is a thick whorl of rather long, stout setae and on the ventral face near the distal third a rather thick group of long, rather strongly curved, slender setae; terminal segment somewhat produced, with a length nearly three times its diameter and tapering gradually to a sub-acute apex (no knob as in *D. cocci)* Palpi: the first segment short, the second with a length about twice its diameter, and the third a little longer than the second. Mesonotum dark reddish brown; scutellum and postscutellum yellowish orange; abdomen "orange red"; the sclerites yellowish

brown; wings hyaline; halteres pale yellowish, fuscous subapically; coxae and femora basally pale yellowish, the remainder of the legs dark straw; claws moderately stout, strongly curved, unidentate; the pulvilli about one-half the length of the claws; ovipositor short, the lobes broadly oval and clothed sparsely with rather coarse hairs.

Pupa. Length 1.5 mm. Rather stout, yellowish orange, the antennal cases extending to the middle of the thorax; the wing cases to the third abdominal segment and the leg cases to the fourth and fifth abdominal segments; posterior extremely broadly rounded, with a median furrow, the abdominal segments dorsally each with a rather broad, transverse band of scattering weak spines.

Larva. Length 1.5 mm. Moderately stout, yellowish orange (probably reddish orange in life); head short, mostly retracted; the breastbone weakly developed, bilobed anteriorly, the lobes rather broad, broadly rounded and roundly excavated at the internal basal angles; the shaft weakly and irregularly developed; the posterior extremity obsolescent; near the middle of each segment there is a transverse row of moderately long, tapering, setose processes; skin rather finely shagreened, posterior extremely broadly rounded.

Type Cecid. A3176, New York State Museum.

The larvæ, as noted by Prof. Wheeler, live under a web in small groups. The pupae occur intermixed and can be distinguished from larvae only with difficulty. The midges doubtless emerge directly from these shelters.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 9

(Tropical Research Station Contribution Number 103)

A NEW BLEPYRUS

By C. T. Brues

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

December 24, 1921

A NEW BLEPYRUS

By C. T. Brues

Blepyrus tachigaliæ sp. nov.

Female. Length 1.5 mm. Head metallic green, thorax black with an æneous cast, abdomen bronzed black; antennæ yellow and black, the scape and funicle yellow, darker on the scape basally, the pedicel and club black; coxæ black, femora black with brown tips, tibiæ brownish yellow with a black streak at base, tarsi pale, with the last joint dark. Wings deeply infuscated basally, hyaline on apical half. Front one-fourth the width of the head at middle, broader above and below, with large punctures forming about four vertical rows; malar furrow shallow and not very distinct; cheeks finely, vertically aciculated, eyes with short pubescence. Antennæ inserted close to the mouth, the scape reaching barely halfway to the vertex, excavated and distinctly, although not broadly, produced below; pedicel triangular, longer than thick and half as long as the funicle; funicle joints about equal in length, the apical joint more than twice as broad as the basal one; club enlarged, flattened and obliquely truncate at apex, as long as the pedicel and funicle together. Thorax, including scutellum, highly convex when seen in profile, the mesonotum nearly as long as the scutellum, the surface of both shining, minutely punctulate and finely hairy; axillary suture apparently obsolete; scutellum very long, the side margins straight till near the apex, which is therefore rather sharply rounded. Abdomen very short, concave above, with long, scattered hairs at the sides. Legs stout, the spur of middle tibia strong, as long as the first tarsal joint, the tarsal spinules strong on all four basal joints. Marginal vein short, not over twice as long as thick; stigmal vein long, postmarginal slightly shorter, their angle of separation about 100 deg.; wing cilia short, those on the costa longer.

Type and paratype bred from *Pseudococcus bromeliæ* Bouché, occurring in cavities in the petioles of *Tachigalia* sp. at Kartabo, British Guiana.

This species agrees well with Howard's original generic diagnosis[1] except that the antennal scape is slightly enlarged below as in certain species of *Bothriothorax* (e. g., *B. minor* Silvestri). The color of the body, appendages and wings will distinguish the present form.

[1] Proc. U. S. Nat. Mus., Vol. 21, p. 233 (1898).

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 10

(Tropical Research Station Contribution Number 104)

TWO TACHIGALIA MEMBRACIDS

By Herbert Osborn

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

December 24, 1921

TWO TACHIGALIA MEMBRACIDS

By Herbert Osborn

***Endoastus* (?) *productus* sp. nov.**

(Fig. 17.)

Head produced before the eyes, about as long as width between the eyes, distinctly furrowed above and below and bifid at tip, ocelli close to front margin of eye, antennæ below the eye in distinct sockets with raised margin; pronotum strongly convex, sloping to head, posterior angles subacute; scutellum triangular slightly longer than basal width; elytra narrow, scarcely reaching end of abdomen; legs short cylindric, all of nearly equal length.

The color is uniformly dark brown except tibiæ, which are lighter, the surface of body and elytra densely and minutely punctured.

Female genital segment three times as long as preceding; the ovipositor extruded; male subgenital plate narrow, upcurved.

Length of female 5.5 mm., of male 4 mm.

This species has a more produced head than *E. caviceps* Fowl., but there seems to be no good structural character to warrant the formation of a distinct genus for it, and at least until the study of related species shows such distinction it seems proper to place it here.

Superficially it has a strong resemblance to the Cicadellids but in structural characters is obviously Membracid.

Eight specimens, seven females, one male. Kartabo, Bartica District, British Guiana, 1920, feeding on the terminal shoots of young *Tachigalia* trees.

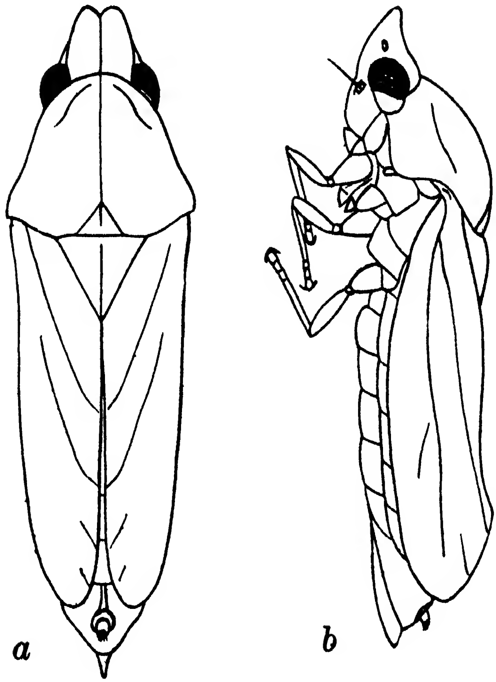


FIG. 17. *ENDOASTUS* (?) *PRODUCTUS* SP. NOV.
FEMALE.
a, dorsal; *b*, lateral aspect.

Microcentrus (?) sp. Nymph.

A single nymph agreeing closely in structural characters with nymphs of *Microcentrus* sps. of Eastern U. S.

Body flattened, slightly convex above, head short, the anterior border with broad, fringed plates each side; abdominal segments 2-6 with flattened, fringed, plate-like expansions and the terminal segment broadly fringed. Length 6.5 mm., width of thorax 3 mm.

Feeding on the terminal shoots of young *Tachigalia* trees Kartabo, B. G., July, 1920.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 11

(Tropical Research Station Contribution Number 105)

A NEW ENTOMOBRYA

By J. W. Folsom

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

December 24, 1921

A NEW ENTOMOBRYA

By J. W. Folsom

Entomobrya wheeleri sp. nov.

(Fig. 18)

Head and body mottled with blue pigment, with no definite color pattern (Fig. 18*a*). Sternum white. Antennæ blue; first three segments darker apically. Coxæ slightly pigmented, also femora distally and tibiotarsi proximally. Furcula unpigmented. Eyes 8-8, on black patches, the two inner proximal eyes of each side being smaller than the others. Antennæ one and three-fifths times as long as the head, with segments in relative lengths about as 9:22:19:30; basal ring large, resembling a segment. Mesonotum not projecting anteriorly. Fourth abdominal segment almost five times as long as the third. Unguis (Fig. 18*b*) with a pair of lateral teeth and with two inner teeth, the proximal tooth being doubled. Unguiculus three-fifths as long as the unguis. Furcula attaining the ventral tube. Manubrium and dentes subequal in length. Dentes crenulate dorsally. Mucrones (Fig. 18*c*) subequally bidentate, the basal spine being absent; two fringed setæ projecting from each dens extend almost to the end of each mucro. Corpus of tenaculum with a single curving ventral seta. General clothing of dense short setæ. Clavate, ringed setæ occur on the anterior part of the head, on the last abdominal segment, and on the dorsal region of the manubrium. Pointed, fringed setæ are present on the last two abdominal segments and on the furcula dorsally and ventrally. A few long, stout, fringed setæ occur on the antennæ, two or three on each coxa, a few on femur and tibiotarsus, and several on the anterior surface of the ventral tube. Length 1 mm.

The preceding description applies only to the largest specimen as regards proportions and pigmentation, for these characters vary according to the age of the individual, as usual. Thus in a specimen 0.39 mm. in length, there is scarcely any blue pigment, the fourth antennal segment being, however,

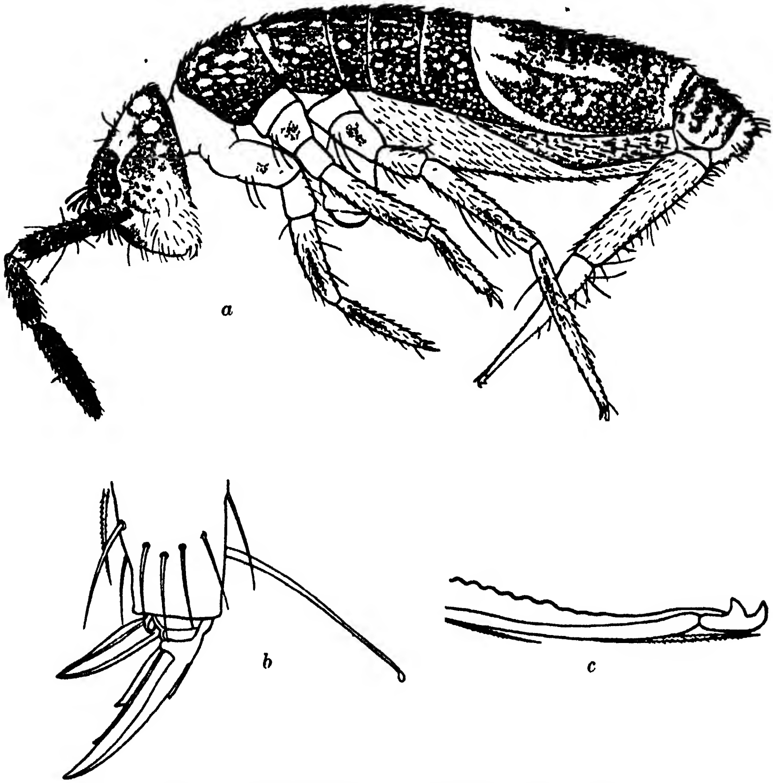


FIG. 18. *ENTOMOBRYA WHEELERI* SP. NOV.
a, lateral view, X 41.5; *b*, left hind foot, X 386; *c*, left mucro, X 386.

faintly tinged apically with blue; the eyes are pigmented separately instead of collectively; the antennæ are subequal to the head in length, with segments short and stout, in relative lengths as 4:5:5:11; while the fourth abdominal segment is only two and two-thirds times as long as the third. In an individual 0.6 mm. in length, the ratio between the third and fourth abdominal segments is as 1:4.

Described from four cotypes, which have been deposited in the Museum of Comparative Zoology, Cambridge, Mass.

I take pleasure in naming this new collembolan after Professor W. M. Wheeler, who found it living with colonies of a peculiar social beetle, *Coccidotrophus socialis* Schwarz and Barber, at Kartabo, in British Guiana.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBER 12

(Tropical Research Station Contribution Number 106)

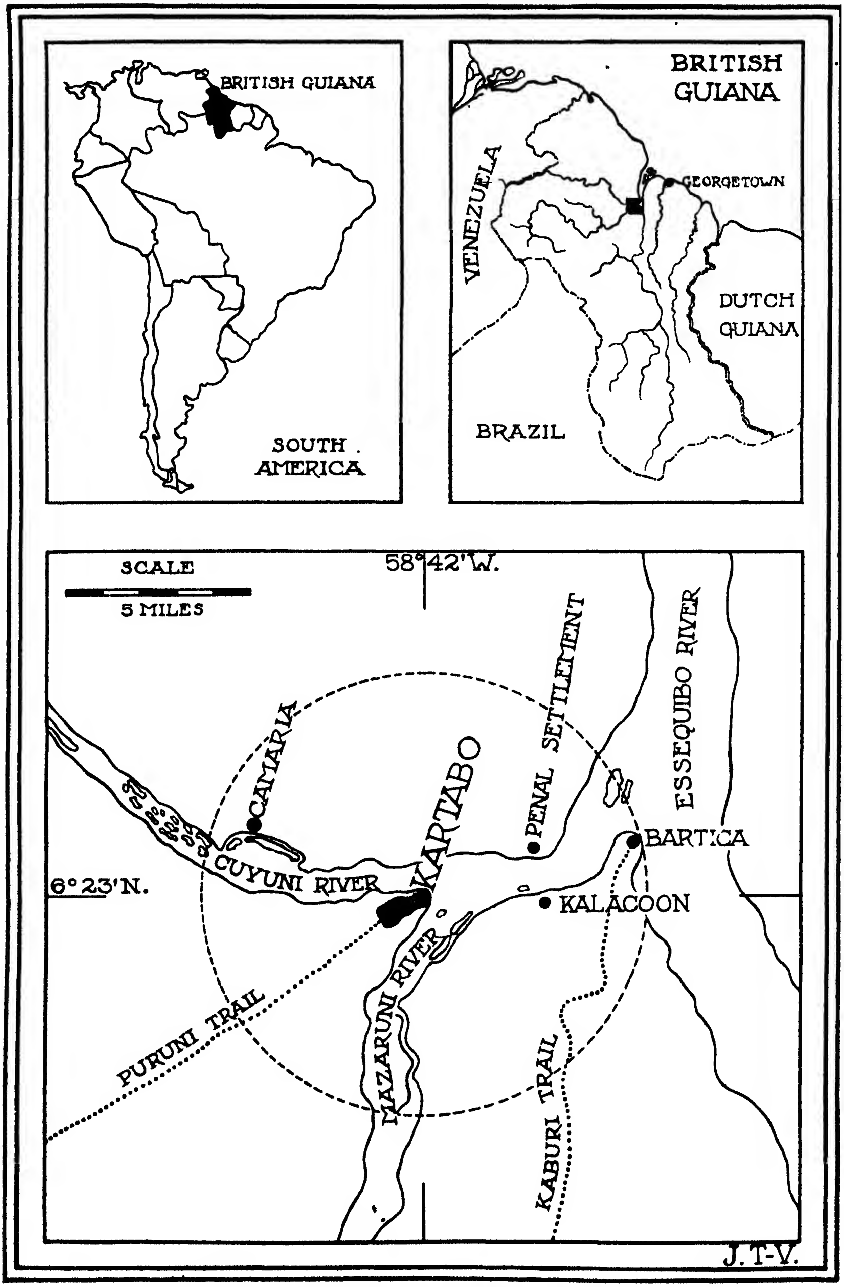
FETUSES OF THE GUIANA HOWLING MONKEY

By ADOLPH H. SCHULTZ

Research Associate, Department of Embryology, Carnegie Institution of Washington.

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

DECEMBER, 1921



LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

Volume III, Nuwber 12

FETUSES OF THE GUIANA HOWLING MONKEY

BY ADOLPH H. SCHULTZ

Research Associate, Department of Embryology, Carnegie Institution of Washington.

Our knowledge of the development of the monkey is still very limited. This is especially true in regard to platyrrhines, most of the scanty literature dealing with Old World monkeys. Just as in the case of human development, more work has been done on the early than on the later stages of fetal development. It is only through a complete knowledge of the entire intrauterine development of the different monkey genera, however, that we may hope to understand fully their position in the system of primates, their relation to each other, and their various specializations and differences, problems of equal importance to the zoologist, as well as to the comparative anatomist and scholar of evolution. Furthermore, such knowledge will prove of great interest to the embryologist and physical anthropologist, who may derive therefrom a clearer insight into the laws governing growth and the conditions of development of the various parts of the body.

The following notes form a small contribution in this direction; they comprise a description of two older fetuses of a howling monkey from South America. These specimens were given by Mr. William Beebe, Director of the Tropical Research Station of the New York Zoological Society, to the Carnegie Laboratory of Embryology. In addition to the fetuses, use has been made of observations on the skeleton of an adult male Alouatta, lent by Mr. Beebe, and another skeleton of an adult and two preserved bodies of juvenile male Alouattas from the anatomical collection of the University of Zürich. The author wishes to take this opportunity to express his sincerest thanks to Mr. Beebe for this valuable material, and to Prof. W. Felix for his kind permission to study the specimens of the Anatomy in Zürich.

The sub-species of monkey to which the fetuses and one of the skeletons (No. 4) belong is *Alouatta seniculus macconnelli* Elliot, the Guiana howling monkey (Beebe, '19). The other skeleton

(No. 3) and the two preserved bodies (Nos. 1 and 2) are of the species *Alouatta seniculus* L.[1] The rarity of the fetuses is increased by the fact that they are twins, twinning in monkeys being to all appearances not any more frequent than in man.[2] From an examination of the fetal membranes it is evident that the fetuses are monozygotic or single-ovum twins. Both are males and one of them is slightly larger than the other, their respective sitting-heights (crown-rump lengths) being 111 mm. (twin A) and 105 mm. (twin B). To what actual age this size corresponds it is impossible to tell. The duration of pregnancy in Alouatta is probably not more than five months,[3] and the fetuses in question had reached certainly the second half of their intrauterine development. Through a careful comparison with the human it is found that the development of these monkey fetuses corresponds most closely with that of a human fetus of twenty weeks, but no doubt they are actually younger. In respect to the state of development of the lanugo, the ears, genitals, hands and feet, and of ossification, the Alouatta fetuses are analogous to human fetuses of the twentieth week, but the latter are considerably larger, their sitting-height being on an average 154 to 164 mm.

[1] The sub-species of these cannot be determined.

[2] Selenka ('92) mentions one case of twins in a *Cercocebus cynomolgus* and Fitzsimons ('19) records two instances of twins in *Papio porcarius* and one in *Cercopithecus pygerythrus*.

[3] Bluntschli ('13) gives the duration of pregnancy for Cebus and Chrysothrix as 4½ to 5 months.

TABLE 1.

ABSOLUTE MEASUREMENTS OF THE ALOUATTA FETUSES

No.	Measurement (in millimeters):	twin A.	twin B.
1.	Sitting height: Top of head to lowest point on buttocks	111	105
2.	Thoraco-abdominal height: Symphysion (upper border of symphysis pubis) to suprasternal notch..........	52.5	47
3.	Symphysion to nipple (the latter projected on midsagittal plane)	47	40
4.	Symphysion to omphalion (center of attachment of umbilical cord)	18	14.8
5.	Biacromial diameter: Distance between the acromial processes	30	28.5
6.	Bimammillary diameter: Distance between nipples.....	21	18.8
7.	Bitrochanteric diameter: Distance between the great trochanters	21.7	21
8.	Transverse diameter of chest (at nipple height).......	27.7	26.4

9. Sagittal diameter of chest (at nipple height)	24	23.8
10. Circumference of chest (at nipple height)	87	84
11. Length of upper arm: Top of caput humeri to humero-radial joint (radiale)	32	31
12. Length of forearm: Radiale to tip of styloid process (stylion)	27.2	26.9
13. Length of hand: Middle of line combining styloid processes of radius and ulna to tip of middle finger	25.7	23.3
14. Length of thumb: Stylion to tip of thumb	15.2	14.8
15. Breadth of hand (across metacarpo-phalangeal joints (II to V)	12	11.3
16. Length of thigh: Top of great trochanter to lateral point of knee joint	30.6	29.6
17. Length of leg: Medial point of knee joint (tibiale) to tip of internal malleolus	25.5	25
18. Tibiale to sole of foot	31.3	29.9
19. Length of foot: Heel to tip of longest toe	33	32.1
20. Breadth of foot (across metatarso-phalangeal joints II to V + breadth of this joint on great toe)	13	12.8
21. Greatest length of head: Glabella to most distant point on head	39.4	38.1
22. Greatest breadth of head: (over temporal or parietal bones)	32	31
23. Auricular height of head: Tragion (upper border of tragus) projected on midsagittal plane to vertex (perpendicular to ear-eye horizon)	21.5	21.2
24. Nasion-inion diameter: Point over middle of naso-frontal suture (nasion) to occipital protuberance (inion)	39.2	38.1
25. Biauricular breadth: Width between the tragion points	31	29.6
26. Horizontal circumference of head (greatest circumference passing through glabella)	115	110
27. Sagittal arc: Nasion to inion	61	56.9
28. Transverse arc: Tragion to tragion (perpendicular to ear-eye horizon)	67.5	64.3
29. Total head height: Lowest point of chin (gnathion) to vertex (perpendicular to ear-eye horizon)	37	36.2
30. Total face height: Nasion to gnathion	17.2	17
31. Upper face height: Nasion to middle of mouth	12.3	12.4
32. Bizygomatic breadth: Greatest breadth between zygomatic arches	31	29.8
33. Nasal height: Nasion to subnasal point (where nasal septum and upper lip meet)	9.3	9.7
34. Nasal breadth: Greatest breadth between nasal wings	9.4	9.2
35. Breadth of nasal septum: Smallest distance between nostrils	3.8	3.6
36. Interocular breadth: Distance between medial angles of eyes	8	7.9
37. Breadth of mouth	15	13.5
38. Length of ear: Highest point on helix to lowest point on lobule	12.7	12.4
39. Breadth of ear: Greatest breadth between anterior and posterior border of helix	9	8.6

TABLE 2. INDICES OF FETAL, JUVENILE, AND ADULT ALOUATTA AND OF HUMAN FETUSES THE NUMBERS IN PARENTHESIS IN THE FORMULAE REFER TO THE NUMBER OF THE MEASUREMENT IN TABLE 1

No	INDEX	Formula	*Alouatta seniculus macconnelli* Fetuses		*Alouatta seniculus*			*Alouatta senicul maccon*	Average of nine negro Fetuses 20th Week
					Bodies Juveniles		Skeletons Adults		
			Twin A	Twin B	1	2	3	4	
I	Relative biacromial diameter	$\frac{(5)}{(2)} \times 100$	57 1	60 6	43 3	41 3			70 5
II	Relative bitrochanteric diameter	$\frac{(7)}{(2)} \times 100$	41 7	44 7	45 0	45 2			54 3
III	Relative circumference of chest	$\frac{(10)}{(2)} \times 100$	165 6	178 6	121 6	145 2			207 2
IV	Thoracic index	$\frac{(8)}{(9)} \times 100$	115 4	110 9	102 3	98 0			119 1
V	Relative bimammillary diameter	$\frac{(6)}{(8)} \times 100$	75 8	71 2	90 5	89 8			62 5
VI	Relative position of nipple	$\frac{(3)}{(2)} \times 100$	89 6	85 1	100 0	101 6			77 1
VII.	Relative position of umbilicus	$\frac{(4)}{(2)} \times 100$	34 3	31 5					19 3
VIII	Relative length of upper extremity	$\frac{(11)+(12)+(13)}{(2)} \times 100$	161 6	172 6	167 4	166 2			142 4
IX	Humero radial index	$\frac{(12)}{(11)} \times 100$	85 0	86 8	87 5	86 3	88 0	91 4	78 2
X	Forearm hand index	$\frac{(13)}{(12)} \times 100$	94 5	86 6	88 0	87 7		79 9	78 7
XI	Relative length of thumb	$\frac{(14)}{(13)} \times 100$	59 2	63 6	62 1	59 5		57 5	69 5
XII	Hand index	$\frac{(15)}{(13)} \times 100$	46 7	48 7	35 0	38 0			51 3
XIII	Relative length of lower extremity	$\frac{(16)+(18)}{(2)} \times 100$	117 8	126 5	134 1	130 9			130 0
XIV	Femoro tibal index	$\frac{(17)}{(16)} \times 100$	83 4	84 5	87 3	87 6	88 8	92 8	82 1
XV	Leg Foot index	$\frac{(19)}{(17)} \times 100$	129 3	128 4	115 8	121 0		100 0	83 2

XVI	Foot index	$\frac{(20)}{(19)} \times 100$	39 4	39 9	30 0	32 6			41 6
XVII	Intermembral index	$\frac{11)+(12)+(13)}{(16)+(18)} \times 100$	137 0	136 4	124 8	126 8			109 7
XVIII	Femoro humeral index	$\frac{(11)}{(16)} \times 100$	104 5	104 7	96 2	98 8	99 4	97 8	91 4
XIX	Tibio-radial index	$\frac{(12)}{(17)} \times 100$	106 6	107 5	96 4	97 2	98 5	96 4	87 2
XX	Foot-hand index	$\frac{13)}{(19)} \times 100$	77 9	72 6	73 2	70 4		77 0	82 5
XXI	Relative size of head	$\frac{(26)+27+(24)+(28)+25)}{3 \times (1)} \times 100$	94 2	94 9	69 6	72 7			105 3
XXII	Head trunk index	$\frac{21)+(22)+(23)}{3 \times (2)} \times 100$	59 0	64 0	39 0	40 7			71 2
XXIII	Cephalic index	$\frac{(22)}{(21)} \times 100$	81 2	81 4	81 7	76 1			85 7
XXIV	Length-height index of head	$\frac{23)}{(21)} \times 100$	54 6	55 6	52 5	53 7			74 9
XXV	Sagittal vault index	$\frac{(24)}{(27)} \times 100$	64 3	67 0	77 9	72 8			49 9
XXVI	Face trunk index	$\frac{(30)}{(2)} \times 100$	32 8	36 2	33 3	33 3			35 6
XXVII	Relative size of upper face	$\frac{(31) \times 3}{(26)+(27)+(24)+(28)+(25)} \times 100$	11 8	12 4	16 5	15 0			9 8
XXVIII	Vertical cephalo-facial index	$\frac{(30)}{(23)} \times 100$	80 0	80 2	126 9	116 6			58 0
XXIX	Upper face index	$\frac{(31)}{(32)} \times 100$	39 7	41 6	55 6	53 1			37 8
XXX	Relative nasal height	$\frac{(33)}{(31)} \times 100$	75 6	78 2	92 0	92 3			66 4
XXXI	Relative nasal breadth	$\frac{(34)}{(32)} \times 100$	30 3	30 8	27 3	24 5			28 0
XXXII	Nasal index	$\frac{(34)}{(33)} \times 100$	101 1	94 8	53 5	50 0			111 7
XXXIII	Relative interocular breadth	$\frac{(36)}{(32)} \times 100$	25 8	26 5	22 2	19 4			28 5
XXXIV	Ear index	$\frac{(39)}{(38)} \times 100$	70 9	69 4	67 8	66 7			63 7
XXXV	Relative size of ear	$\frac{(38) \times (39)}{21) \times 29)} \times 100$	7 8	7 7	14 5	12 1			3 3

For the purpose of comparing the outer form of the Alouatta fetuses with that of the human fetus and of older Alouattas, and in order to describe the proportions of the former fetuses in an exact, numerical way, a series of measurements has been taken and indices of these have been formed. The technique of meas-

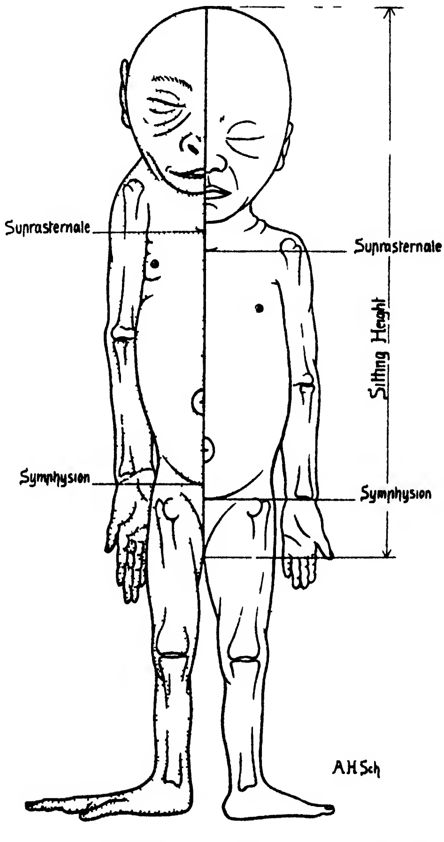


FIG. 19. SCHEMATIC DRAWING OF ALOUATTA FETUS (DOTTED HALF) AND NEGRO FETUS OF TWENTY WEEKS, REDUCED TO SAME SITTING-HEIGHT.

uring and the formulae for the indices, as well as the measurements and indices themselves, are compiled in tables 1 and 2. In drawing conclusions from these tables one has to be careful on account of the scarcity of the material and the considerable variability thereof. When more material is available, especially

different genera and different stages of development, such conclusions will become safer and more extensive. In this paper I intend chiefly to place on record a detailed and accurate description of the two monkey fetuses and also to sketch in a preliminary way the changes during growth and some results of the comparison with human fetuses. The averages of the above tabulated measurements and of those of the human fetuses were used for the construction of a schematic drawing (Fig. 19) which may serve to illustrate the following remarks concerning the body proportions of the Alouatta fetuses.

The length of the trunk relative to the sitting-height is the same in the Alouatta fetus as in the human fetus; however, the different transverse diameters of the trunk, and the circumference of the chest are all relatively considerably smaller in Alouatta, which accounts for the slender appearance of the trunk in the latter. The adult condition is well expressed in the fetuses by the fact that, in relation to the length of the trunk, the width between the shoulders, as well as between the hips, is very much smaller in the Alouatta than in the human fetus. We know that, with the exception of the gorilla, man has the widest shoulders and hips of any of the adult primates. The shoulders of the Alouatta fetus are not only relatively closer together but they are also very much higher than in the human fetus, which fact constitutes a very marked difference between the two types. The thoracic index shows only a slight difference; in both types the transverse diameter of the chest surpasses the sagittal diameter. The somewhat larger average in human fetuses, however, points to a much more marked difference in later stages of growth, when the thorax is much broader in man than in any platyrrhine monkey, the latter having a deep and narrow chest. The nipples of the Alouatta fetus are considerably higher and more laterally situated than in the negro;[4] this close proximity of the mammae to the axillae is characteristic for most New World monkeys. The extreme in the very high and lateral position of the nipple in Alouatta is not reached until postnatal life, when the nipple may lie above the level of the suprasternal notch. The umbilicus of Alouatta lies relatively much higher than in the human fetus. From our findings on the trunk it is apparent that there exist

[4] The nipple of the Alouatta fetus lies over the third rib, in the human fetus between the fourth and fifth rib.

differences between the Alouatta and the human fetus in every point except in the relative length of the anterior wall of the trunk. The greatest differences consist in the shorter transverse diameters of the trunk, and the higher position of the shoulders, the nipples, and the umbilicus in the Alouatta.

The upper extremity is relatively considerably longer in the Alouatta than in the human fetuses; it reaches practically no farther down in Alouatta but is, as shown above, inserted higher than in human fetuses. In this difference in length the various parts composing the arm participate to a different degree. The relatively greatest difference exists in the length of the hand; somewhat less is the difference in the forearm, and least of all in the upper arm, but all three are relatively longer in the Alouatta. The relations of these parts to each other are expressed in the humero-radial and forearm-hand indices; according to the former, the radius, relative to the humerus, is longer in Alouatta, and according to the latter the hand, in relation to the forearm, is also very much longer in the monkey fetus. The humero-radial index in the adult Alouatta amounts to 91 according to Mollison ('10) and to 88 to 91.4 according to table 2. These figures are higher than the corresponding ones for the fetuses; therefore, the forearm in Alouatta has a greater rate of growth than the upper arm. According to the forearm-hand index, which in Alouatta decreases during growth, the hand has a slower rate of growth than the forearm. The human hand, in contrast to the hand of other primates, is characterized by its relatively greater breadth. This difference is already present in our fetuses, the hand index being larger in the human. During postnatal development the hand of Alouatta becomes still more slender. The length of the thumb in relation to the length of the hand is considerably less in the Alouatta than in the human fetuses, and this relation does not seem to change markedly during growth. The reduction of the thumb, typical for most monkeys, is, therefore, recognizable in fetal life. In the Alouatta fetuses fingers II to V are, in relation to the metacarpus, very much longer than the human fingers. Finger III is the longest but IV is almost as long, and finger II reaches about as far as finger V.

The lower extremity is relatively little shorter in the Alouatta, both femur and tibia being slightly shorter than in the negro fetuses. This minute difference is at first rather surprising, in consideration of the fact that man's lower extremity is relatively by far the longest of all primates. However, this distinction does not fully appear until some time during postnatal growth. The relation of the tibia to the femur is also only slightly different, the relative length of the tibia of the Alouatta being somewhat greater than of the negro fetus. During postnatal development the femoro-tibial index in Alouatta increases steadily. Martin ('14) states that this index increases during growth in all human races; it may, therefore, be concluded that the lower leg has a more intense rate of growth than the thigh, not only in man but also in Alouatta. The foot of the Alouatta is very much longer than that of the human fetus, and this, indeed, is one of the most marked differences between the body proportions in the two types. This difference is very pronounced in the relation of the foot length to the length of the tibia. The human foot is relatively the shortest of all the primates and this most probably holds true in fetal stages also. In both Alouatta and man the leg-foot index decreases markedly during growth. The fetal Alouatta foot is narrower and more slender than the foot of the human fetus. In the former the great toe is very much shortened, the second and third toes are of equal length, and the heel is not prominent.

In summarizing the results of this comparison of the extremities in Alouatta and human fetuses the greater length of the upper extremity in the Alouatta fetus and the approximately equal length of the lower one are points especially noteworthy. This different behavior in the relation of the upper to the lower extremity is precisely expressed in the intermembral index, which amounts to 136.7 in the Alouatta and to only 109.7 in negro fetuses. This index decreases during postnatal development in Alouatta as well as in man. The most distal portions of the extremities, the hand and the foot, in the Alouatta surpass in length the corresponding members of the human fetus to a greater extent than the more proximal parts. The thumb and the great toe especially is less developed in the Alouatta than in the human fetus.

It remains to consider briefly the proportions of the head. Here the most striking feature consists in the smaller size of the brain part of the head of the Alouatta as compared with the human fetus, a difference which is especially manifest in the height. There is a greater difference in the breadth than in the length of the head, as shown by the smaller cephalic index of the Alouatta, and a very much greater difference in height than in either of the other diameters, as shown in the length-height index, which is very much smaller in the Alouatta; the length, therefore, shows the least difference of any of the head diameters. The height of the face, from nasion to chin, is equal in the two types; the upper-face height is somewhat greater in the monkey, and the anterior part of the mandible is therefore less developed in height than it is in the human fetus. The breadth of the face shows but little difference, but the mouth is very much broader in Alouatta. The external nose is higher as well as broader in the monkey fetuses, the greater difference existing in height, so that the nasal index becomes considerably larger in the human fetuses. The low nasal index of our monkey fetuses is not restricted to platyrrhines, but is also found in fetuses of catarrhines and apes (Schultz, '20), in which also the nose is high relative to its width. In regard to the fetal nasal index, therefore, man seems to occupy an exceptional position among the primates. The relative interocular breadth is greater in adult man than in any adult monkeys or apes; it is therefore not surprising that the human fetus surpasses in this respect the Alouatta fetus, although not to such a degree as it would in the adult stage. The relative interocular breadth decreases in both Alouatta and man during growth. The nasal septum is very much broader in the Alouatta fetuses, which already show the typical features of the platyrrhine nose with laterally pointing nostrils. The ear of the Alouatta is considerably larger than that of the human fetus, a difference which becomes very evident when the size of the ear is expressed in percentage of the size of the head. The ear of the juvenile Alouatta is relatively almost twice as large as that of the fetus. In relation to its length, it is somewhat broader in the latter than in the average human fetus of that stage. The external meatus is situated farther back on the head in the monkey fetus. A further point of interest

FIG 20 FRONT AND RIGHT SIDE VIEW OF HEAD OF ALOUATTA FETUS (TWIN A) APPROX. NATURAL SIZE

in the latter is the finding, on the lateral surface of the auricular fold, immediately behind the anthelix, of two low and not very distinct longitudinal folds, which without doubt, correspond to the (five) folds found by Schwalbe ('97) in human fetuses of four months. Figure 20 illustrates the typical features of the head of the Alouatta fetuses.

Following is a condensed description of points of interest on the integument of the Alouatta fetuses. In the latter, in contrast to human fetuses, there is no philtrum nor labial tubercle and the visible part of the mucous lips is extremely narrow. The lanugo of the Alouatta fetuses at this stage of development is restricted to the head. Very fine and short sparse hair is found on the forehead and over each zygoma in front of the ears. Longer, and somewhat more strongly developed hair occurs in the region of the chin and on the upper lip. These, with the exception of a few black ones on the upper lip, are very light. The eyebrows are formed by long, almost bristle-like sinus hairs, which are entirely black on the medial portions of the brows; the lateral parts consist of hairs black in their lower part and light at the end. A few of the outermost hairs in the brows are entirely light. There are no anlagen for sinus hairs on the cheeks of these twin fetuses, but such were found by Frédéric ('06) in three out of five Alouatta fetuses. No papillary ridges can be made out on the palms, soles, or ventral side of the tail; these apparently do not occur until later in fetal development.

The arrangement of pads (touch balls) and epidermal folds on the palm and sole is shown in figure 21. The finger nails, as well as the toe nails, are well developed and curved, in both longitudinal and transverse directions, especially in the latter, and resemble claws.

FIG 21 RIGHT HAND AND FOOT OF ALOUATTA FETUS (TWIN A), TWICE NATURAL SIZE

A few remarks concerning the degree of resemblance between these twin fetuses of Alouatta may be of interest. One frequently finds the assumption that monozygotic twins are "identical", and this is especially expected in fetuses in which environmental conditions have not exerted an influence, as they do in postnatal life. Newman ('17) has collected sufficient proofs to show that absolute identity is never found, even in single-ovum twins. In comparing the columns for twin A with those for twin B in tables 1 and 2, it is at once apparent that there is no identity in the proportions of their bodies. All of the absolute measurements of A are larger than the corresponding ones of B with two exceptions—the upper-face height and the nasal height, which are slightly greater in twin B. The degree of resemblance between twins is most accurately obtained by figuring out the

average percentage difference for all the absolute measurements taken. This is done according to the following formula:

$$\left\{ \sum \frac{\text{m A} - \text{m B}}{\frac{1}{2}(\text{m A} + \text{m B})} \times 100 \right\} \div \text{n}$$

A stands for twin A, B for twin B, m for measurement, and n for the number of measurements used—in our case 39. The result thus obtained is 4.81, i. e., a measurement of twin B differs on an average from the corresponding measurement of twin A 4.81 percent. This rather high percentage is naturally affected by the difference in absolute size in general between the twins, but even if this were equalized, considerable difference would remain, as shown by the fact that the indices, likewise differ. The author's experience with human monozygotic twins, especially those of fetal stages, is analogous to that gained on these monkey twins, inasmuch as human twins also show upon closer examination a great number of more or less marked deviations. Finally, I may state that so far, I have never found human single-ovum twins, of any state of development, with exactly the same general size. This is also the case in the Alouatta twins, one being larger than the other.

For a study of the ossification and of the cartilaginous parts of the skeleton, X-ray photographs were taken of one of the Alouatta fetuses and the other one (twin A) was stained with toluidin blue and cleared in a three percent solution of potassium hydroxide and afterward placed in glycerine, a process which, in addition to the ossified parts, shows the cartilage in a dark blue color. For some points it became necessary also to partly dissect one of the fetuses in order to observe in detail certain conditions of the skeleton. Figure 22 is an exact drawing of the cleared specimen and may serve to illustrate the following description.

The spinal column consists of 57 vertebrae; 7 cervical, 14 thoracic, 5 lumbar, 3 sacral, and 28 caudal. These numbers occurred also in all the other Alouattas examined, with the exception of skeleton 3, which has only 27 caudal vertebrae. In table 3 the lengths of the different spinal regions are expressed in percentages of the praecaudal length of the spine. From the

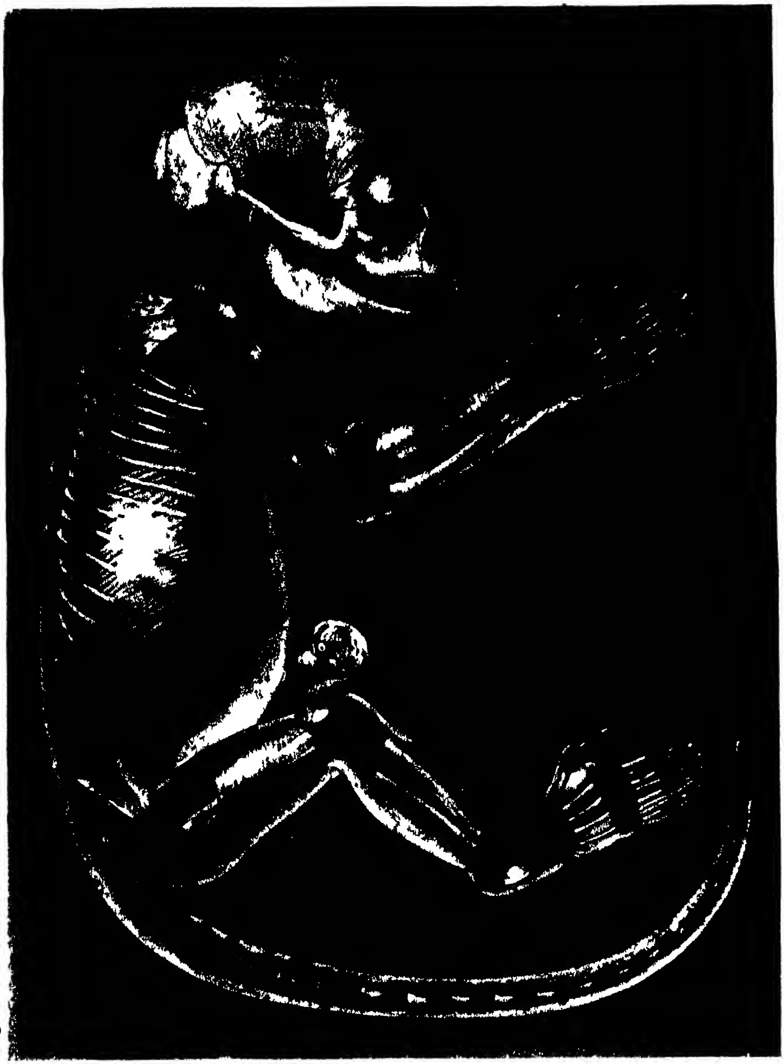


FIG. 22. SIDE VIEW OF CLEARED ALOUATTA FETUS, SHOWING THE SKELETON. NATURAL SIZE

figures in this table it can be concluded that the cervical and the sacral regions of the Alouatta fetus are shorter than in human fetuses, whereas the thoracic region is considerably longer in the former than in the latter. It is furthermore of interest to note that in both Alouatta and man during growth the relative

length of the thoracic region decreases, while the lumbar and sacral regions increase. In Alouatta the length of the caudal region is relatively greater in adults than in fetuses. This relatively greater rate of growth of the tail is also well expressed in the following percentage relations of the length of the latter to the sitting-height: Fetus A 109.0, fetus B 113.3, juvenile Alouatta (No. 1) 165.0, and juvenile Alouatta (No. 2) 165.7. Toldt ('03) found that the relative length of the tail changed very little during growth in case of *Macacus cynomolgus* L. This suggests the possibility that, whereas the tail of Alouatta is in a state of progressive evolution, that of Macacus is stationary, if not regressive, a suggestion which may be supported by the fact

TABLE 3. LENGTHS OF THE DIFFERENT SPINAL REGIONS IN PERCENTAGES OF THE PRAECAUDAL LENGTH OF THE SPINE IN ALOUATTA AND MAN.

	Region of spine:				
	cervical	thoracic	lumbar	sacral	caudal
Alouatta seniculus macconnelli.... fetus (twin B)	17.0	49.3	22.7	11.0	133.5
Alouatta seniculus juv. (No. 1)...	13.4	47.5	26.0	13.1	186.7
Alouatta seniculus ad. (No. 3)....	14.8	45.1	27.3	12.8	160.0
Alouatta seniculus macconnelli.... adult (No. 4)	17.4	43.2	26.6	12.8	161.3
Human fetuses of 20 weeks.......	21.0	41.5	22.0	15.5	....
Human adults (Martin, '14)......	16.0	39.0	25.0	19.0	....

that in the genus *Macacus* there are several species with an almost rudimentary tail. In the spine of the Alouatta fetus each vertebra contains one ossification center for the body and, down to the fifth caudal vertebra one for each hemiarch. There are 14 ribs on each side, which are well ossified, their osseous shafts having about the same proportional length in regard to the costal cartilages as they have in the adult stage. The first eight pairs of ribs reach the sternum; the next two pairs are asternal ribs, and the remaining four pairs are floating ribs; even the last pair is still fairly long. This arrangement of ribs is the rule in the juvenile and the adult Alouatta also, with the exception of skeleton 3, in which only seven pairs of ribs reach the sternum and five pairs are floating ribs, the last pair being very short. The

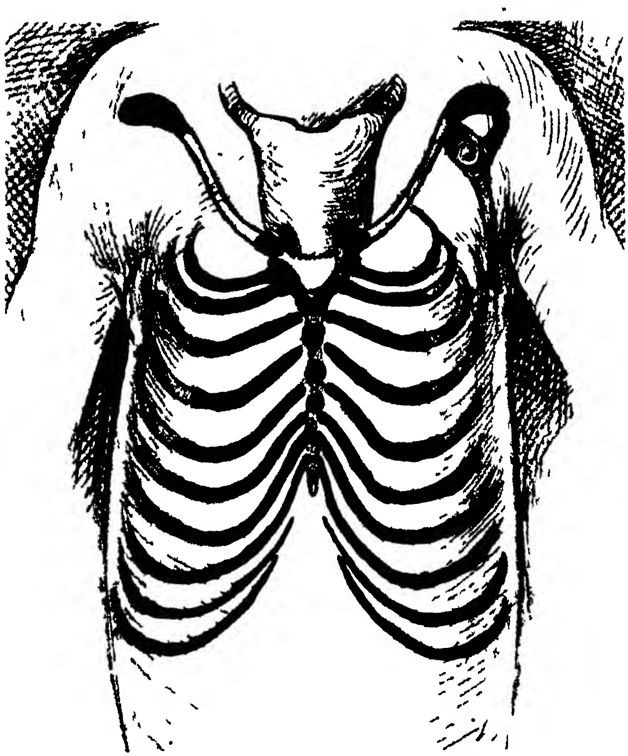


FIG 23 SKETCH OF STERNUM OF ALOUATTA FETUS

sternum as yet shows no ossification centers. It is a slender cartilaginous structure in which only three ring-shaped zones and one uppermost, V-shaped zone are stained. The sternum of the adult Alouatta is distinguished by a unique condition—a splitting of the manubrium, due to the enormous development of the hyoid and larynx. It is extremely interesting to find this condition already present in the fetus. The cranial end of the fetal sternum forks into two diverging processes to which the two uppermost pairs of ribs and the clavicles are attached. Between these halves of the manubrium emerges the trachea from the thorax, and immediately above and almost in front of them lies the large hyoid (see figure 23). In the adult the second rib inserts somewhat lower on the sternum, not, as in the fetus, on the lateral process itself, but on the base of the latter, or even slightly below the forking of the two processes. The clavicles are well ossified

and are curved S-shaped, very similar to that in the human fetus. The scapula has a greatest length equal to its greatest breadth, whereas in the adult state the breadth surpasses the length (from the glenoid cavity to the vertebral margin). The vertebral margin above the dorsal end of the spina scapulae is approximately one-half the length of the portion of this margin below the spine of the scapula. The latter portion of the vertebral margin has a concave contour, thus forming a scaphoid scapula. The acromial and coracoid processes are cartilaginous without ossification centers, as are also the dorsal edge and glenoid cavity of the scapula. The pelvis contains two pairs of ossification centers, one in the ilia and the other in the ischia; the pubic portion of the pelvis as yet shows no sign of ossification. The blades of the ilia are long and slender.

All the shafts of the long bones of the extremities are well ossified; there are no ossification centers in any of their epiphyseal ends. The humerus has no foramen entepicondyloideum, which is found in *Cebus* and other platyrrhines. On the humeri of the skeleton No. 3 there is a foramen supratrochleare on each side, but this is missing in the other specimens of *Alouatta* examined. The torsion of the fetal humerus, i. e., the angle between the axes of the caput and of the trochlea, amounts to 90 degrees, which is less than the torsion in human fetuses of corresponding development, in which I found this angle to vary from 98 to 130 degrees. The proximal end of the olecranon projects considerably beyond the incisura semilunaris, whereas the olecranon in the human fetus ends abruptly at the proximal end of the latter incisura. An analogous difference in the olecranon is found between modern adult man and adult monkeys, and it is interesting to see this distinction already clearly defined in fetal stages. The tibia in its upper portion shows a rather marked backward bend (proximal retroflexion). The carpus consists entirely of cartilage and contains a well-developed centrale, which at this stage of human development has disappeared from the wrist. Among the tarsial cartilages the calcaneus possesses a rather extensive ossified zone. In the human fetus this ossification center normally does not occur until the sixth month; this seems to be the only point in which the state of ossification of the Alouatta fetuses does not coincide with that of the human

FIG 24 SKULL OF AN OLD ALOUATTA SENICULUS WITH FORAMEN TEMPORALE AT X

fetuses of twenty weeks. At the distal end of each metacarpus and of the first metatarsus sesamoid cartilages are to be found.

Most of the elements of the skull of the Alouatta fetuses are already ossified to a considerable extent; apparently only the petrosum forms an exception in this respect. The great fontanelle sends a gradually narrowing arm almost as far as the naso-frontal suture and posteriorly communicates by a fairly broad arm with the occipital fontanelle; both are rather large. The two pairs of lateral fontanelles are small. From the frontal bone a process reaches toward the alisphenoid separating the parietal from the malar bone, a condition usually found in Alouatta, but contrary to the rule in other platyrrhines. The lacrimal fossa is situated almost outside of the orbit and is in full view when looking at the skull from in front. The foramen zygomatico-faciale is very wide. Where the orbital plate of the zygomaticum and the alisphenoid meet there is a foramen zygomatico-temporale of considerable size. This foramen has been described by Joseph ('76), who found it in all adult New World monkeys. It represents a vestige of the complete communication between temporal and orbital fossae found in Lemuroidea. The foramen is closed by a true membrana obturatoria orbitae. In

our fetuses this foramen communicates by a narrow arm with the fissura orbitalis inferior, thus actually forming a continuation of the latter, which constitutes a more conspicuous remnant of the former full communication between the two fossæ. In the squama temporalis of the Alouatta fetus, over the root of the zygomatic arch, a fine foramen is to be found (x in figure 22). This foramen may correspond to that noted by v. d. Broek ('08) in the squama temporalis of *Ateleus.* I observed that the presence of this foramen is not restricted to the genus *Ateleus* but occurs also in many other platyrrhines.[5] Among the skulls of New World monkeys of my collection I found the foramen at a corresponding place and of relatively large size in eight *Alouatta seniculus* L. (see figure 24), including both juvenile and very old animals, in two species of *Ateleus,* and in one *Aotus boliviensis* Elliot. It was missing in all skulls of *Cebus* and of *Hapale* which I examined. This foramen is formed by an emissary vein; it may be called *foramen temporale.* In the skull of the very old *Alouatta seniculus macconnelli* (No. 4) no trace of it could be seen. This, and the fact that in the fetus of the same sub-species there is only an extremely fine foramen in the squama temporalis, which may be merely a foramen nutritium, makes it possible that this sub-species of *Alouatta seniculus* has no true foramen temporale. The ramus mandibulæ is broad and rather high; in later stages of growth this portion of the mandible of Alouatta increases enormously in size, enclosing the greatly enlarged hyoid. The hyoid capsule in the fetus is still cartilaginous, but already of a quite extraordinary size. The nasal cartilages are well developed and differentiated. The lateral nasal cartilage is of triangular shape and the greater alar cartilage encircles the nostril almost entirely, whereby its greatest surface is directed forward instead of sidewise, as in catarrhines.

The most interesting conclusion of this study is the fact that most of the typical differences existing between adult man and adult Alouatta—be it those of outer form or those of the skeleton—are already well defined in fetal stages, although not yet as pronounced as in the adult.

[5] A rather large foramen on the corresponding place was found by the author in two human adult skulls of his collection (Nos. 266, white, and 216, negro).

BIBLIOGRAPHY

BEEBE, W.

1919 The higher vertebrates of British Guiana. Zoologica. Scientific contributions of New York Zool. Soc., Vol. II, No. 7.

BLUNTSCHLI, H.

1913 Entwicklungsgeschichte platyrrhiner Affen, von Didelphis marsupialis, Tamandua . . . Anat. Anzeiger, Vol. XLIV, Ergzh., p. 196.

V. D. BROEK, A. J. P.

1908 Ueber einige anatomische Merkmale von Ateles, in Zusammenhang mit der Anatomie der Platyrrhinen. Anat. Anzeiger, Vol. XXXIII, p. 111.

FITZSIMONS, F. W.

1919 The natural history of South Africa. Vol. I. London.

FREDERIC, J.

1906 Nachtrag zu den "Untersuchungen über die Sinushaare der Affen." Zeitschr. f. Morph. u. Anthrop., Vol. IX, p. 327.

JOSEPH, G.

1876 Ueber die äussere Seitenwand der Augenhöhle bei den amerikanischen Affen. Morphol. Jahrb., Vol. I, p. 454.

MARTIN, R.

1914 Lehrbuch der Anthropologie. Jena.

MOLLISON, TH.

1910 Die Körperproportionen der Primaten. Morphol. Jahrb., Vol. XLII, p. 97.

NEWMAN, H. H.

1917 The biology of twins (mammals). University of Chicago Science Series.

SCHULTZ, A. H.

1920 The development of the external nose in whites and negroes. Contrib. to Embryology, No. 34. Pub. 272, Carnegie Institution.

SCHWALBE, G.

1897 Das äussere Ohr. Handb. d. Anatomie d. Menschen, Bardeleben. Vol. V, p. 130.

SELENKA, E.

1892 Affen Ostindiens. Studien über Entwicklungsgesch., H. 5, 2nd half. Wiesbaden.

TOLDT, C.

1903 Ueber die äussere Körperform zweier verschieden grosser Embryonen von Macacus cynomolgus L. Arch. f. Anthrop., Vol. XXVIII, p. 277.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH
STATION IN BRITISH GUIANA

VOLUME III, NUMBER 13

(Tropical Research Station Contribution Number 108)

MAMMALS COLLECTED BY WILLIAM BEEBE AT THE BRITISH GUIANA TROPICAL RESEARCH STATION

By H. E. ANTHONY.

Associate Curator of Mammals of the Western Hemisphere
American Museum of Natural History

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

DECEMBER 24, 1921

MAMMALS COLLECTED BY WILLIAM BEEBE AT THE BRITISH GUIANA TROPICAL RESEARCH STATION

By H. E. ANTHONY.

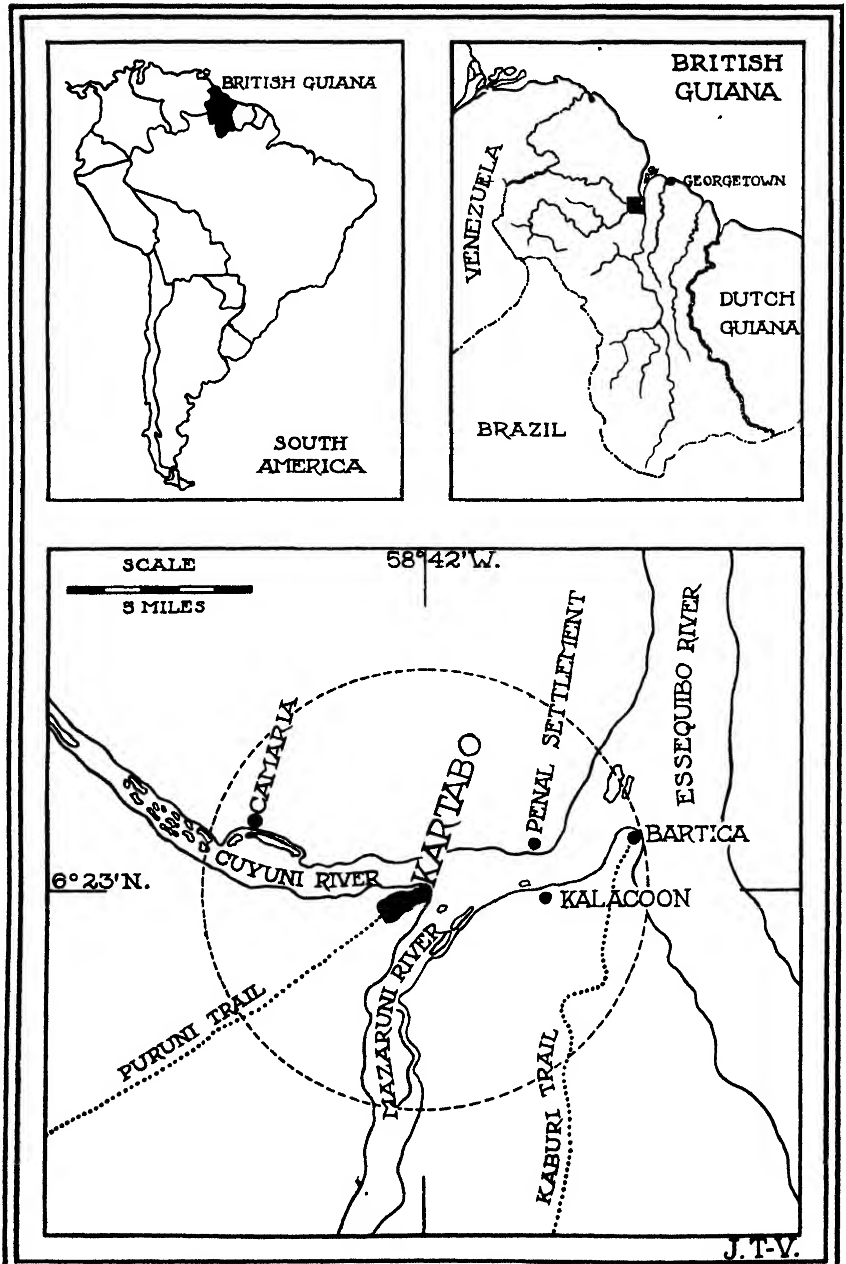
Associate Curator of Mammals of the Western Hemisphere
American Museum of Natural History

When the New York Zoological Society established a Tropical Research Station in British Guiana, with Mr. William Beebe as Director, an arrangement was made whereby the Department of Mammals of the American Museum was to receive such specimens of mammals as might be collected from time to time.

The first work of the Station was done in 1916, and has been carried on at intervals ever since, resulting in the accession of some five hundred and twenty-one specimens of mammals. The collecting has been done, for the most part, at three points, Kartabo, Kalacoon and the Penal Settlement, all, as shown on the accompanying map, lying within a small area forty-five miles inland from the coast. This region is included in the humid, tropical, rain forest zone[1] and is a most important locality, not alone for the richness of the mammalian fauna but because of the great historical value which attaches to specimens secured from northeastern South America. Many of the classical species, many of the forms described by Linnæus, have their habitat somewhere within this general region, so that a series from the Guianas may be considered as typical.

The work of the Station staff was so occupied by their own particular problems that the collecting of mammals was an incidental feature and, in consequence, the list of species secured there is far from complete. On the other hand, the aggregate amount of time spent at the Station has resulted in the accumulation of large series of some species, and a very gratifying

[1]For photographs and details of this region see, "Tropical Wild Life in British Guiana", William Beebe, N. Y. Zool. Soc., 1917, and Zoologica, III, 1921, No. 1, by Henry Fairfield Osborn.



LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

number of rarities. Four forms new to science were taken and in addition there are ten species new to the museum collections. In all fifty-six species and subspecies are represented. No small part of the value to be attached to this collection lies in the number of skeletons preserved, since there are skeletons for nearly all of the species represented by a series of any size.

In the identification of this collection, I have received valuable assistance from Mr. Gerrit S. Miller of the United States National Museum, through the loan of comparative material, while I am indebted to Dr. Wilfred H. Osgood of the Field Museum, for opinions on some nomenclatural points.

1. *Didelphis marsupialis marsupialis* Linnæus.

1758. *Didelphis marsupialis* Linnæus, Syst. Nat., I, p. 54, (part).
1902. *Didelphis marsupialis* Allen. Bull. Amer. Mus. Nat. Hist., XVI, p. 257.

Six specimens: Kartabo, 5 skins, 4 skulls, 1 skeleton.

2. *Marmosa chloe* Thomas.

1907. *Marmosa chloe* Thomas. Ann. and Mag. Nat. Hist., (7) XX, p. 167.

Seven specimens: Kartabo, 7 skins, 6 skulls, 4 skeletons.

These animals are practically topotypes of *chloe,* since this species was described from the Demerara river, 29 miles above Georgetown.

3. *Marmosa cinerea demerarae* Thomas.

1905. *Marmosa cinerea demerarae* Thomas. Ann. and Mag. Nat. Hist., (7), XVI, p. 313.

Eight specimens: Kartabo, 7 skins, 4 skulls, 5 skeletons.

The series, which includes both adults and half grown young, agrees quite closely with the type description of *demerarae,* type locality, Comackka, eighty miles up the Demerara River.

4. *Metachirus nudicaudatus nudicaudatus* (Geoffroy).

1803. *Didelphys nudicaudata* E. Geoffroy. Cat. Mus., p. 142.

Immature specimen: Kartabo, skin with skeleton.

5. *Monodelphis brevicaudata brevicaudata* (Schreber).

1778. *Didelphys brachyuros* Schreber. Säug. III, 549 pl. cli (plate published in 1777).
Peramys brevicaudata auctorum.

One specimen: Kartabo, skin with skeleton.

The material for comparison with this specimen of *Peramys* is too inadequate to enable me to do more than assign it provisionally to *brevicaudata,* on the assumption that the animal of the Guiana lowlands is Schreber's species. Judging from the limited series of red *Peramys* in the collection from Venezuela and British Guiana, there exists either a very great degree of individual variation or else a need for additional new species.

6. *Bradypus cuculliger* Wagler.

1831. *Bradypus cuculliger* Wagler, Isis, p. 605.
1871. *Arctopithecus cuculliger* Gray, Proc. Zool. Soc. London, p. 440.

Eight specimens: Kartabo, 5 skins, 5 skulls, 2 skeletons; Kalacoon, 1 skin; Kyk-over-al, 1 skin, 1 skull.

This series is referred to *cuculliger* upon the basis of the descriptions given in the two references cited above, and with regard to the fact that Gray had a specimen from Demerara which he called *cuculliger.* The agreement with the descriptions is fairly close and the series averages darker in color than a series of *tridactylus flaccidus* from Venezuela; but the color pattern is rather similar to that of *flaccidus,* in fact so similar that, should my identification of *cuculliger* be correct, I believe that *flaccidus* should stand as a subspecies of *cuculliger* and not of *tridactylus.* Compared with specimens of *tridactylus* from Santarem, Brazil, the Guiana specimens are radically different in the coloring of the head, throat and neck.

7. *Choloepus didactylus* Linnæus.

1766. ***Bradypus didactylus*** **Linnæus. Syst. Nat., I, p. 51.**

Two specimens: Kalacoon, 1 skin, 1 odd skull.

8. *Myrmecophaga tridactyla* Linnæus.

1758. ***Myrmecophaga tridactyla*** **Linnæus, Syst. Nat., p. 35.**

One of these anteaters was brought back alive and placed in the New York Zoological Park. It has since died and is now in the Museum collection. It was taken at Kartabo and was only about half grown.

9. *Tamandua tetradactyla tetradactyla* (Linnæus).

1766. ***Myrmecophaga tetradactyla*** **Linnæus, Syst. Nat. I, p. 52.**

Twelve specimens: Kartabo, 9 skins, 10 skulls, 2 skeletons; Kalacoon, 1 skin, 2 skulls.

The color of the pelage of these anteaters varies so considerably that, were the two extreme examples to be considered alone, they might well be thought to be distinct from one another. The dark dorsal area is almost completely absent from one specimen which in consequence greatly resembles the yellow *longicaudata*. However, the apparent gap between this yellow specimen and the darkest of the series, is well bridged over by the specimens of intermediate coloration. The shape of the nasals, used as a character of separation between *longicaudata* and *tetradactyla*, varies almost as much as does the color of the pelage, the narrowest examples being no wider than the nasals of *longicaudata* from Maripa, Venezuela.

10. *Cyclopes didactylus didactylus* (Linnæus).

1766. ***Myrmecophaga didactyla*** **Linnæus, Syst. Nat. I, p. 51.**

One specimen: Penal Settlement, skin and skeleton.

11. *Dasypus novemcinctus novemcinctus* Linnæus.

1766. ***Dasypus novemcinctus*** **Linnæus, Syst. Nat. I, p. 54.**

Four specimens: Kartabo, 4 skins, 4 skulls, 2 skeletons.

These are all half grown young.

12. *Tatu kappleri* (Krauss).

1862. *Dasypus kappleri* Krauss, Archiv. Naturg., Vol. I, p. 24.

Three specimens: Kartabo, 2 skins, 1 skull; Kalacoon, 1 skin with skeleton.

These are the first specimens of *kappleri* to be received in the Museum's collection. This species is widely different from *Dasypus novemcinctus*, which it resembles somewhat superficially. Aside from a slight difference in size, *kappleri* being the larger, it has only eight movable bands instead of nine, it has two rows of spur-like scales on the hind legs which are entirely wanting on *novemcinctus*, a rudimentary fifth toe on the fore foot, longer ears and noticeably different skull characters, the most important of which is the peculiar flange-like margins of the posterior palate.

13. *Tayassu pecari beebei* Anthony.

1921. *Tayassu pecari beebei* Anthony, Amer. Mus. Novitates, No. 19, p. 1.

Eight specimens: Kartabo, 7 skins, 7 skulls, 2 skeletons.

General Characters.[2]—Closely related to *pecari pecari*, but differing in the extent of white on the snout and lower jaw.

Description.—Coloration about as in *p. pecari* but white of face and throat markings more yellowish; long hairs of upper parts brownish black; snout, above, only slighter lighter in color than rest of upper parts and not with strongly contrasting whitish of *p. pecari;* chin and throat patch restricted and not in such marked contrast to the surrounding areas; feet dark to hoofs. Skull as in *p. pecari.*

Measurements.—Taken from animal in flesh: total length, 1090 mm.; tail vertebrae, 60; hind foot, 224; weight 80 pounds.

This subspecies was described upon the basis of the restricted white areas upon the nose and throat. It is closely related to true *pecari* of Brazil, and was named in honor of Mr. William Beebe, the Director of the Tropical Research Station.

14. *Pecari tajacu macrocephalus* Anthony.

1921. *Pecari tajacu macrocephalus* Anthony, Amer. Mus. Novitates, No. 19, p. 3.

Eight specimens: Kartabo, 5 skins, 6 skulls.

---

[2]This description, together with those of the other three new species, appeared first in American Museum Novitates, No. 19, by H. E. Anthony.

General Characters.—Similar to *tajacu* but with skull larger and markedly different in structure.

Description.—Pelage about as in *tajacu*, grizzled yellowish and black, with black dorsal area; collar fairly well outlined.

Skull larger than that of *tajacu*, with more massive build, the forward extension of the zygomatic flange continued to canine alveolus and forming a heavy rostrum; outline of entire skull noticeably subtriangular viewed either from above or below, due to extended zygomatic flange; palate throughout anterior portion wider than distance across the molar series of that portion.

Measurements.—Taken in the flesh: total length 948 mm.; length of hind foot, 195.

Macrocephalus has been set off from typical *tajacu* because of important cranial differences. The Kartabo skulls have wide zygomatic flanges, which extend well out on the rostrum and give to the skull a subtriangular outline, when viewed from above or below. The skulls of true *tajacu* from Brazil have much slenderer rostra and the outline is flask-like.

15. *Mazama americana tumatumari* Allen.

1915. *Mazama americana tumatumari* Allen, Bull. Amer. Mus. Nat. Hist., XXXIV, p. 536.

Two specimens: Kartabo, 1 skin with skull; Kalacoon, 1 skin, spotted.

The specimen in the adult pelage appears to agree with the type, from Tumatumari, which is at no great distance from Kartabo and Kalacoon.

The very young specimen, which is only a flat skin without skull, is very brightly colored with numerous and conspicuous buffy spots.

16. *Mazama nemorivaga* (F. Cuvier).

1817. *Cervus nemorivagus* F. Cuvier, Diction. Sci. Nat. VII, p. 485 (part, the Cayenne specimens only).

1915. *Mazama nemorivagus* Allen, Bull. Amer. Mus. Nat. Hist. XXXIV, p. 548.

Nineteen specimens: Bartica, 1 skin; Kartabo, 11 skins, 9 skulls, 1 skeleton; Kalacoon, 4 skins, 2 skulls, 2 skeletons.

There is considerable variation in color shown by this large series, although all are some shade of light brown. The varia-

tion consists chiefly in a more or less extensive darkening of the dorsal area and, to a lesser degree, in the intensity of the dark coloring on the legs. Four young, in the spotted coat, are included in the series, the youngest of which is very conspicuously spotted but the oldest is only very faintly marked and about to assume a pelage like that of the adult.

17. *Hydrochœrus hydrochœrus* (Linnæus).

1776. *Sus hydrochœrus* Linnæus, Syst. Nat., I p. 103.

Two immature specimens: Kartabo, skins with skeletons.

These specimens are too young, being about the size of *Sylvilagus*, to give any characters.

18. *Dasyprocta aguti flavescens* (Thomas)

1898. *Dasyprocta rubrata flavescens* Thomas, Ann. and Mag. Nat. Hist., (7), II, p. 274.

Thirty-four specimens: Kartabo, 20 skins, 33 skulls, 1 skeleton; Kalacoon, 1 skull.

This large series exemplifies the degree of variation found in the genus. The intensity of coloration on the rump varies from ochraceous—orange to Sanford's brown (Ridgway, Color Standards and Nomenclature); the extent of the bright area is often considerably reduced by the encroachment of the darker colored hairs of the upper dorsal region; the nape and shoulders, while normally quite dark, are sometimes much lighter and the degree of punctulation is far from constant.

Mr. Oldfield Thomas has referred[1] the northern Guiana agoutis to the above species, mentioning among his specimens a large series from Demerara. Specimens in our collection from Tumatumari, British Guiana, are indistinguishable from the Kartabo series, although they had previously been identified as *lucifer cayennae*. I agree with Mr. Thomas that the Guiana specimens have nothing to do with Wagler's *prymnolopha*, since none of the large series of *flavescens* before me

[1]1917, Ann. and Mag. Nat. Hist., (8), XX, p. 259.

shows any tendency toward the development of a black rump patch, which is a very conspicuous feature of *prymnolopha*.

19. *Agouti paca paca* (Linnæus).

1766. *Mus paca* Linnæus, Syst. Nat., I, p. 81.

Two specimens: Kartabo, skins with skulls.

These specimens are provisionally identified as *paca* but it is possible that they represent *fulvus* of Cuvier. Owing to a scarcity of suitable material from northeastern South America, and to the rather confusing status of the group as set forth in literature, the wide range of individual variation making identification from written descriptions most difficult, I have thought it best to assign the Guiana material to *paca*.

20. *Proechimys cayennensis* (Desmarest).

1817. *Echimys cayennensis* Desmarest, Nouv. Dict., X, p. 59.

Eleven specimens: Kartabo, 4 skins, 3 skulls, 4 skeletons; Kalacoon, 1 skin; Samiri Island, Mazaruni River, 6 skins.

The relationships of *cayennensis*, as given by Thomas[4], are with *trinitatis*, and this series of spiny rats from Guiana bear considerable resemblance to the rats from Trinidad, both superficially and in cranial characters.

21. *Echimys longirostris* Anthony.

1921. *Echimys longirostris* Anthony, American Museum Novitates, No. 19, p. 5.

One specimen: Kartabo, skin and skeleton.

General Characters.—Most like *armatus*, but differing in characters of pelage and in significant details of cranial structure, having much longer nasals and shallow postpalatal notch.

Description.—Pelage spiny, but with many unmodified hairs which partially mask the spines; hairs on crown only slightly spinous; color above, a mixture of black, ochraceous and buff, the ochraceous strongest on nose and face and posterior to shoulders along dorsal area; black strongest on neck and shoulders; flanks lighter than dorsal area and merging insensibly into the grayish under parts; hairs of underparts subspinous, gray at base and tipped with buff; pectoral area more brightly colored than posterior

[4] 1903, Ann. and Mag. Nat. Hist., (7), XI, p. 491.

under parts; hands and feet grizzled gray, buff and ochraceous, dirty white distally; tail haired at base for about 50 mm., colored same as rump, scaly for rest of its length, sparsely haired, practically unicolor, ashy in color.

Skull elongate with convex superior outline; nasals long, slender, subcylindrical; lateral margins of temporals forming straight lines, not concave; postpalatal notch U-shaped, reaching scarcely beyond the posterior margin of last molar; molar pattern typical of the genus.

Measurements.—Taken from dried skin; total length 466 mm., tail vertebræ 225; hind foot 38.

Although no less than three different names have been employed for the *Echimys* of British Guiana, the types have been determined to be specifically identical so that *guianae* and *castaneus* stand as synonyms of *armatus*. The Kartabo *Echimys* could be identified under none of these names and it was necessary to make it a new species. A fair amount of comparative material representing all three of these names has been available but no specimen was found which had such long nasals nor such a great interorbital breadth.

22. *Mus musculus musculus* Linnæus.

1758. *Mus musculus* Linnæus, Syst. Nat., I, p. 62.

Twelve specimens: Kartabo, 1 skin; Georgetown, 11 skins, 5 skulls.

23. *Rattus rattus alexandrinus* (Geoffroy).

1818. *Mus alexandrinus* Geoffroy, Descr. Egypt, II, 733.

Twenty-three specimens: Georgetown, 17 skins, 9 skulls, 3 skeletons; Penal Settlement, 6 skins, 3 skulls, 1 skeleton.

24. *Œcomys guianæ* Thomas.

1910. *Œcomys guianæ* Thos. Ann. and Mag. Nat. Hist., (8) VI, p. 187.

Two specimens: Kartabo, 2 skins, 1 skeleton.

These specimens agree with the description of *guianæ* closely enough to be so identified and they were taken sufficiently near to the type locality of *guianæ*, River Supinaam, to be considered topotypical.

25. *Œcomys nitedulus* Thomas.

1910. *Œcomys nitedulus* Thos. Ann. and Mag. Nat. Hist., (8) VI, p. 505.

Three specimens: Kartabo, 3 skins, 1 skull, 1 skeleton.

The type locality of *nitedulus* is the lower Essequibo River, thirteen miles from mouth, which is not very distant from Kartabo. The specimens from Kartabo are none of them old adults and consequently appear to be a trifle smaller than the measurements given by Thomas.

26. *Œcomys rutilus* Anthony.

1921. *Œcomys rutilus* Anthony, Amer. Mus. Novitates, No. 19, p. 4.

One specimen: Kartabo, skin with skeleton.

General Characters.—A small, brightly colored species, with very short tail and clear white under parts.

Description.—Color above, between amber brown and hazel (Ridgway), darkest along dorsal area and on crown, the hairs slaty black for basal two-thirds; below, clear white, the hairs white to the base; hands and feet dirty white, almost dusky; dark orbital ring with small dark area at posterior corner of the eye, tail brownish, unicolor. Skull small and broad, rostrum very short, zygomata flaring, a low supra-orbital beading.

Measurements.—Taken in the flesh: total length, 171 mm.; tail vertebrae, 94; hind foot, 20. Greatest length of skull, 24.2; zygomatic breadth, 13.5; length of nasals, 7.7; interorbital breadth, 4.4; breadth of brain case, 11; palate, to incisors, 10; palatal foramina, 3.7x2.2; length of upper molar series, 3.4.

This is a small, brightly colored mouse, of the genus *Œcomys*, quite distinct from the other *Œcomys* collected there, *nitedulus*, and possibly a relative of *rosilla* Thomas, from which it differs however in clear white underparts.

27. *Neacomys guianæ* Thomas.

1905. *Neacomys guianæ* Thomas, Ann. and Mag. Nat. Hist., (7) XVI, p. 310.

Two specimens: Kartabo, 2 skins, 1 skull, 2 skeletons.

These specimens are essentially topotypes since Thomas gives the type locality as the Demerara River, altitude 120 feet.

28. *Nectomys squamipes melanius* Thomas.

1910. *Nectomys squamipes melanius* Thomas, Ann. and Mag. Nat. Hist., (8) VI, p. 185.

Twenty-three specimens: Kartabo, 7 skins, 6 skulls, 6 skeletons; Kalacoon, 1 skin; Kyk-over-al, 11 skins, 8 skulls, 4 skeletons; Samiri Island, Mazaruni River, 4 skins.

The series agrees quite closely with the description of the type, and as the type locality is given as the lower Essequibo River, twelve miles from mouth, the Beebe specimens are practically topotypes.

29. *Oryzomys velutinus?*

1893. *Oryzomys velutinus* Allen, Bull. Amer. Mus. Nat. Hist., V, p. 214.

Ten specimens: Kartabo, 10 skins, 3 skulls, 3 skeletons.

The short-haired *Oryzomys* of the Beebe collection are provisionally referred to *velutinus,* although it may be questioned whether *velutinus* is not truly insular and the name not to be used for mainland forms. Without specimens of Lund's *laticeps* for comparison, and because of the confusing status of the *Oryzomys* of northeastern South America, these specimens are so named now, merely for the sake of convenience, but it is quite possible that more material will show them to be a subspecies of *laticeps*. These specimens agree quite closely with *velutinus* from Trinidad.

30. *Oryzomys* sp.?

One specimen: Bartica, skin, without skull.

This is a large species, strongly ochraceous above and buffy white below. It is not unlike *trinitatis* in general appearance, and on the other hand it agrees fairly well with the type description of *macconnelli*[5] but appears to be rather too small in size.

31. *Oryzomys* sp.?

Two specimens: Kartabo, 2 skins, 1 skull.

[5] 1910. Thomas, Ann. and Mag. Nat. Hist., (8) VI, p. 186.

These two specimens are of the *meridensis* group and possibly are closely related to *caracolus* Thomas[6] described from near Caracas, Venezuela.

32. *Guerlinguetus æstuans æstuans* (Linnæus).

1766. *Sciurus æstuans* Linnæus, Syst. Nat., I, p. 88, (Surinam).

1915. *Guerlinguetus æstuans æstuans* Allen, Bull. Amer. Mus. Nat Hist., XXXIV, p. 256.

Five specimens: Kartabo, 5 skins, 3 skulls, 2 skeletons.

This series is especially acceptable since this species of the Guiana lowlands has hitherto been very poorly represented in the Museum collection.

33. *Procyon cancrivorus cancrivorus* (Cuvier).

1798. *Ursus cancrivorus* Cuvier, Tabl. Elem. Hist. Nat., p. 113.

Two specimens: Penal Settlement, 2 skins, 2 skulls, 1 skeleton.

34. *Potos flavus flavus* (Schreber).

1775. *Lemur flavus* Schreber, Saug. I., p. 145, pl. 42.

Two specimens: Kalacoon, 1 skin, 1 odd skull.

35. *Lutra mitis* Thomas.

1908. *Lutra mitis* Thomas, Ann. and Mag. Nat. Hist., (8), I, p. 393.

Three specimens: Kartabo, 1 skin, 1 skull, 1 skeleton; Kalacoon, 1 skull.

The skin and the skulls seem to agree fairly well with Thomas's description of the type.

36. *Tayra barbara barbara* (Linnæus).

1766. *Mustela barbara* Linnæus, Syst. Nat., I, p. 67.

Four specimens: Kartabo, 2 skins, 2 skulls, 2 skeletons; Kalacoon, 1 skull.

[6] 1914. Ann. and Mag. Nat. Hist., (8) XIV, p. 242.

One specimen has the head and neck above grizzled gray and the chest area dirty whitish; the other has the corresponding areas yellowish above and pale ochraceous below.

The odd skull is unusually large, with a very high sagittal crest, and measures, greatest length, 130 mm.; zygomatic breadth, 78.5 against 107 and 65, the dimensions of an adult female from Kartabo.

37. *Nasua phæocephala* Allen.

1904. *Nasua phæocephala* Allen, Bull. Amer. Mus. Nat. Hist., XX, p. 334.

Four specimens: Kartabo, 3 skins, 3 skulls, 1 skeleton; Kalacoon, 1 skeleton.

These specimens agree well in coloration with the type of *phæocephala*, from Suapure, Venezuela.

38. *Panthera onca* (Linnæus).

1766. *Felis onca* Linnæus, Syst. Nat., I, p. 61.

One specimen: Kartabo, skin and skull, adult male.

Skull measurements: Greatest length, 238 mm.; length of nasals, 57; zygomatic breadth, 160; mastoid breadth, 99; breadth of rostrum, 67; length of upper tooth row to incisors, 95.

39. *Margay tigrina vigens* (Thomas).

1904. *Felis weidii vigens* Thos., Ann. and Mag. Nat. Hist., (7) XIV, p. 192.

1919. *Margay tigrina vigens* Allen, Bull. Amer. Mus. Nat. Hist., XLI, p. 357.

One specimen: Kartabo, skin with skeleton.

This specimen agrees, in most essential characters, with the type description of *vigens* (*loc. cit.*). The skull measurements are a trifle larger for the Kartabo animal and the color pattern varies slightly from that given by Thomas, in the lesser number of dark rings on the tail and the whiter underparts.

40. *Herpailurus yaguarondi unicolor* (Traill).

1819. *Felis unicolor* Traill, Mem. Wernerian Soc., III, p. 170.
1919. *Herpailurus yaguarondi unicolor* Allen, Bull. Amer. Mus. Nat. Hist., XLI, p. 383.

One specimen: Kartabo, skin and skeleton, adult male.

This rare cat is in the black phase and is a glistening black all over, except about the head and neck which is grizzled with gray.

Measurements, taken in the flesh; total length, 1150 mm.; tail vertebræ, 470; hind foot, 155; weight, 19 pounds.

Skull, greatest length, 112 mm.; basal length, 99; zygomatic breadth, 71; breadth of braincase, 43.5; length entire upper tooth row, 42.7.

41. *Saccopteryx bilineata* (Temminck).

1839. *Urocryptus bilineatus* Temminck, Van der Hoeven, Tijdsch. Natur., p. 33.

Three specimens in alcohol: Kalacoon.

42. *Rhynchiscus naso* (Wied).

1821. *Vespertilio naso* Wied, Schinz's Thierreich, Vol. I, p. 179.

Thirteen specimens in alcohol: Kaow Island, Essequibo River, 12; Kartabo, 1.

The collector's notes state that these bats were found "on bark of tree."

43. *Glossophaga soricina soricina* (Pallas).

1766. *Vespertilio soricinus* Pallas, Miscell. Zool., p. 48.

Sixty specimens: Creeklands, Berbice, 28 skins, 20 skulls, 20 skeletons; Georgetown, 6 skins, 16 alcoholics; Kartabo, 10 alcoholics.

This large series of *Glossophaga* presents but little variation in color and appears to be typical *soricina* in every character.

44. *Hemiderma perspicillatum perspicillatum* (Linnæus).

1758. [*Vespertilio*] *perspicillatus* Linnæus, Syst. Nat., I, p. 31.

Fifty-seven specimens: Georgetown, 10 skins; 29 alcoholics; Kalacoon, 4 alcoholics: Kartabo, 14 alcoholics.

This series is quite uniform in character and presents no points worthy of comment.

45. *Mesophylla macconnelli* Thomas.

1901. *Mesophylla macconnelli* Thomas, Ann. and Mag. Nat. Hist., (7), VIII, p. 145.

Seven specimens in alcohol: Kartabo, July 22, 1920.

This genus has hitherto been unrepresented in the Museum collection, but there is little difficulty in identifying it from the description given by Miller in "The Families and Genera of Bats," p. 158. The most conspicuous features of the skull are the swollen maxillaries and depressed nasal region, while the pelage of *macconnelli* is very light colored.

These specimens were taken at no very great distance from the type locality of the species which is Kanuku Mountains, British Guiana.

46. *Phyllostomus hastatus hastatus* (Pallas).

1767. *Vespertilio hastatum* Pallas, Spici. Zool., III, p. 7.

Three specimens in alcohol: Kartabo, 2; Kalacoon, 1.

47. *Vampyrus spectrum spectrum* (Linnæus).

1766. *Vespertilio spectrum* Linnæus, Syst. Nat., I, p. 46.

One specimen: Kartabo, skin and skeleton.

This very large species is represented by only one specimen which appears to be typical in all respects. The forearm is 104 mm. long.

48. *Furipterus horrens* (F. Cuvier).

1828. *Furia horrens* Cuvier, Mem. Mus., XVI, p. 150.

Six specimens: Kartabo, April 26 to August 25.

This series is a valuable addition to the Museum collection since *Furipterus* is exceedingly rare. The series is uniform in coloration and the average measurement of the forearm is 34.9 mm.

49. *Eumops milleri* (Allen).

1900. *Promops milleri* Allen, Bull. Amer. Mus. Nat. Hist., XIII, p. 91

Two specimens (1 imm.) in alcohol: Kartabo.

The adult specimen agrees fairly well in all characters but size with the type of *milleri*. In cranial characters the two are identical with the following exceptions, the Kartabo specimen has slightly smaller upper incisors and less extensive basicranial pits. The following measurements are of the Kartabo bat, contrasted with the type of *milleri* in parentheses; forearm, 55 mm. (58.7); greatest length of skull, 24.7 (25.2); zygomatic breadth, 14.2 (14.2): length of upper tooth row, C-M^3, 9.3, (9.8).

This specimen is not unlike the type of *Eumops barbatus* (Allen) which differs from *milleri* mainly in size only. Additional material may show that *barbatus* should stand either as a subspecies of *milleri* or as its synonym, and the older name of *milleri* is followed, because of the inadequate material representing *barbatus*, the type being unique.

50. *Molossus obscurus* Geoffroy.

1805. *Molossus obscurus* Geoffroy, Ann. du Mus., VI, p. 154.

Twenty-two specimens: Georgetown, 9 alcoholics; Kalacoon, 1 skin, 9 alcoholics; Kartabo, 3 alcoholics.

Only one specimen of the entire series is in the red phase.

51. *Molossus rufus* Geoffroy.

1805. *Molossus rufus* Geoffroy, Ann. du Mus., VI, p. 154.

Six specimens: Georgetown, 3 skins; Kartabo, 1 alcoholic; Penal Settlement, 2 alcoholics.

These specimens are in the dark phase, and the Kartabo example has a forearm 48 mm. in length.

52. *Saimiri sciureus* (Linnæus).

1758. *Simia sciurea* Linnæus, Syst. Nat. I, p. 19.
1913. *Saimiri sciureus* Elliot, Review of the Primates, I, p. 310.

Five specimens: Kartabo, 3 skins, 2 skulls, 1 skeleton; Kalacoon, 1 skin, 1 skull.

Of the *Saimiri* taken in British Guiana, all but one appear to be typical *sciureus*, the series being fairly uniform in coloration. The exception, a skin without skull, differs in having black lateral stripes on the head and behind the eye, while the dorsal region is a much brighter color than in the other specimens, being quite yellow. This specimen, from Kartabo, I have provisionally identified as *cassaquiarensis*, a considerable extension of range, if the identification proves to be correct, since the range of this species is to the west of British Guiana.

53. *Saimiri cassaquiarensis* (Humboldt).

1811. *Chrysothrix sciureus cassaquiarensis* Humboldt, Rec. Obs. Zool. I, p. 334. (1815)
1913. *Saimiri cassaquiarensis* Elliot, Review of the Primates, I, p. 311.

One specimen: Kartabo, skin without skull.

54. *Alouatta seniculus macconnelli* (Elliot).

1910. *Alouatta macconnelli* Elliot, Ann. and Mag. Nat. Hist., (8), V. p. 80.
1916. *Alouatta seniculus macconnelli* Allen, Bull. Amer. Mus. Nat. Hist., XXXV, p. 233.

Thirty-three specimens: Kartabo, 22 skins, 23 skulls, 8 skeletons; Kalacoon, 3 skins, 7 skulls.

This large series displays a very considerable range of individual variation in color. The general tone of the upper parts varies from yellow to bright orange red, with a corresponding lack of uniformity in the coloration of the limbs and tail, which in some specimens are much darker than the upper

parts, although this condition is not as conspicuous as in true *seniculus*.

A group of eight individuals, six adults and two young, has been mounted and placed on exhibition in the American Museum of Natural History.

55. *Pithecia pithecia* (Linnæus).

1766. *Simia pithecia* Linnæus, Syst. Nat., I, p. 40.
1913. *Pithecia pithecia* Elliot, Review of the Primates, I, p. 293.

Twenty-seven specimens: Kartabo, 17 skins, 19 skulls, 5 skeletons; Kalacoon, 4 skins.

The status of the species of the genus *Pithecia* is far from satisfactory, to judge by the literature and the specimens in the Museum collection, and the present series focuses attention upon this fact. The specimens all were taken in a small area and exhibit considerable variation in coloration. In the males, the color of the head varies in the amount of ochraceous; in one specimen this color extends from the under side to the median line of the upperparts, but the normal color above is a dirty white.

56. *Cebus apella apella* (Linnæus).

1758. *Simia apella* Linnæus, Syst. Nat. I, p. 28.
1913. *Cebus apella* Elliot, Review of the Primates, II, p. 78.

Twenty-five specimens: Kartabo, 15 skins, 23 skulls, 2 skeletons.

Although the range of color variation shown by this series is considerable, the average is darker than that of a series of *apiculatus* from Venezuela. The series shows but little of the fulvous which characterises *apiculatus* and is much darker than *apella brunneus*.

APPENDIX A

By H. E. Anthony

The following four species of mammals, a rat, a mongoose and two bats, were collected at Georgetown, sixty miles away on the coast, and have not as yet been taken at the Station.

Rattus norvegicus (Erxleben).

1777. [*Mus*] *norvegicus* Erxlebon, Syst. Regni Anim., Vol. I, p. 381.

Four specimens: Georgetown, 4 skins, 4 skulls, 2 skeletons.

Mungos birmanicus (Thomas).

1886. *Herpestes auropunctatus birmanicus* Thomas, Proc. Zool. Soc., London, p. 58.
1911. *Mungos birmanicus* G. M. Allen, Bull. Mus. Comp. Zool., LIV, p. 217.

One specimen: Georgetown, skin and skeleton.

It is to be hoped that the mongoose will find enough enemies upon the continental mainland to prevent the widespread distribution and destruction which have followed its introduction into the West Indies.

Artibeus planirostris planirostris (Spix).

1823. *Phyllostoma planirostre* Spix, Sim. et Vesp. Bros., p. 66.
1908. *Artibeus planirostris planirostris* Andersen, Proc. Zool. Soc., London, p. 237.

One specimen: Georgetown, skin and skeleton.

This specimen is best considered as *p. planirostris* on the basis of measurements, although on geographical grounds it should be *p. fallax*. The following measurements, total length of skull, 28.5 mm.; mastoid width, 15.5; width of braincase, 12; maxillary width across m^1, 17.5; upper tooth row, c-m^2, 10; forearm, 61; all come closer to those of the former subspecies than they do to those of the latter, as set forth by Andersen in his monograph of the genus op. cit. page 246.

The skull lacks the m^3 on both sides and it is interesting in this connection to note that three out of four of Andersen's only specimens of the *planirostris* group which lacked m^3 came from British Guiana, page 234, *op. cit.* as did also an "unusually small specimen" of *p. fallax,* page 243.

Macrophyllum macrophyllum (Wied).

1825. *Phyllostoma macrophyllum* Wied, Beitr. zur Naturgesch. Brasilien, Vol. II, p. 188.

One specimen (male) : Georgetown, April.

This specimen is in alcohol and is in excellent condition. The skull has been removed and cleaned for examination. This rare species is well characterized externally by the very high and broad noseleaf, long, slender tragus and very extensive interfemoral membrane, which has a series of longitudinal rows of minute dermal papillæ along the proximal half of the under surface. The most striking cranial characters are the shelf-like surface just anterior to the external nares, the enlarged median incisors above and the greatly reduced second lower premolar, which is scarcely visible to the naked eye.

Length of forearm, 34.5 mm.

APPENDIX B

By William Beebe

The following unmistakable mammals have been observed by me at the Station, or in some cases collected alive or dead, and not preserved. I add them to complete the tentative list of mammals of the Station.

57	*Chironectes* sp.	(Water Opossum)
58	*Desmodus* sp.	(Vampire Bat)
59	*Icticyon* sp.	(Crab-dog)
60	*Felis* sp.	(Puma)
61	*Leopardus* sp.	(Ocelot)
62	*Myoprocta* sp.	(Short-tailed Agouti)
63	*Coendu* sp.	(Tree Porcupine)
64	*Sciurillus* sp.	(Dwarf Squirrel)
65	*Priodontes* sp.	(Giant Armadillo)
66	*Tapirus* sp.	(Tapir)
67	*Trichechus* sp.	(Manatee)
68	*Inia* sp.	(Fresh-water Dolphin)
69	*Leontocebus?* sp.	(Marmoset)
70	*Ateles* sp.	(Spider Monkey)

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH
STATION IN BRITISH GUIANA

VOLUME III, NUMBERS 14 AND 15

Tropical Research Station Contributions Numbers 134 and 135

14. NEW BATRACHIANS
15. NEW LIZARDS

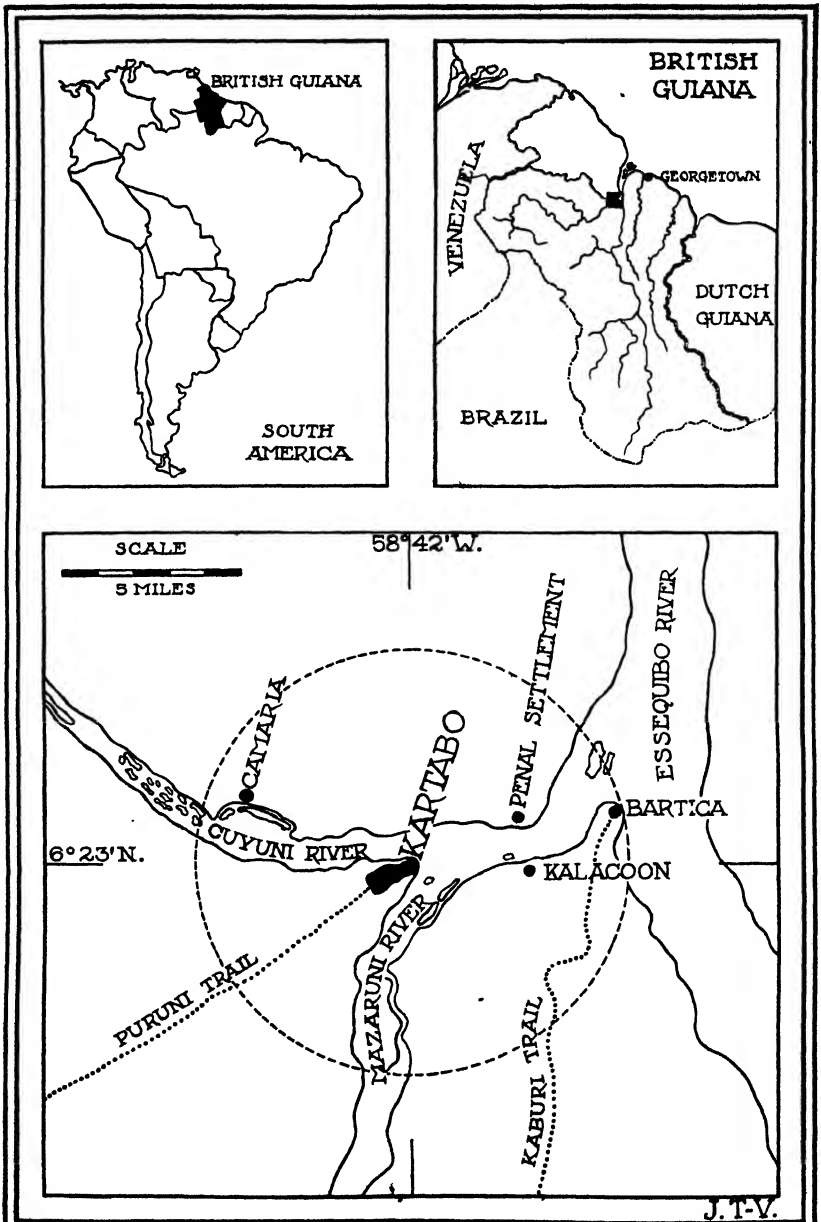
FROM THE TROPICAL RESEARCH STATION BRITISH GUIANA

By G. Kingsley Noble

Associate Curator of Herpetology, in Charge,
American Museum of Natural History

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

September 10, 1923



LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

First form on press September 10, 1923

NEW BATRACHIANS

FROM THE TROPICAL RESEARCH STATION BRITISH GUIANA

By G. KINGSLEY NOBLE
Associate Curator of Herpetology, in Charge,
American Museum of Natural History

Among the Amphibia secured by Mr. William Beebe or by members of his staff while at the Tropical Research Station and substations maintained by the New York Zoological Society in British Guiana, there are included a number of new forms. The reptiles and amphibians collected by Mr. Beebe have already been reported upon in part (Beebe, 1919, Zoologica II, No. 7). Mr. Beebe has been kind enough to place in my hands his new species for description. The present paper deals with only the Amphibia collected. A second paper will consider the new reptiles obtained by Mr. Beebe. It is Mr. Beebe's intention to publish later a full account of the reptiles and amphibians found near the Tropical Research Station, together with a series of colored plates illustrating most of the forms described below. I have added to the following descriptions a diagnosis of one species found at the Zoological Society's Research Substation near the Kaieteur Falls, but represented in the collections at my disposal only by specimens secured by a former expedition.

Hyloxalus beebei sp. nov.

DIAGNOSIS

Readily distinguished from all other species of the genus by its small size, rudimentary webs and brilliant coloration in life. Preserved specimens are straw-color above with a dark stripe on either side of the head and body, and with an irregular stippling of dark brown on the back. From the species of *Phyllobates*, which it closely resembles, this species may be distinguished by the short but well-defined webs between the toes, and by its distinctive coloration.

* Tropical Research Station, Contribution Number 134.

TYPE

A.M.N.H. No. A-18683; adult ♀; near Kaieteur Falls, British Guiana; February 18, 1921; William Beebe.

DESCRIPTION OF TYPE

Size very small; snout rounded, a trifle longer than the greatest diameter of the eye; distance between nostril and tip of snout a trifle less than the distance between nostril and eye; interorbital space one and one-half times as broad as the upper eye-lid; tympanum nearly two-thirds the diameter of the eye, rather indistinct, less than its own diameter from the eye. Tibiotarsal articulations of either side in contact when the legs are placed at right angles to the body; tibiotarsal articulation reaching the posterior border of the eye. Digital dilations very small, the discs less than one-half the diameter of the tympanum; fingers free, the first finger not as long as the second; toes with a short but very distinct rudiment of a web; no fringe extending the length of the toes as in most species of *Hyloxalus*. Two metatarsal tubercles, the outer pointed and one-third the diameter of the inner which is not very distinct; a well-defined tarsal fold. Tongue ovate, slightly nicked behind. Skin smooth above, slightly granular on the sides; no well-defined folds on the back.

Ground tone in alcohol a pale straw-color; streak of dark brown from tip of the snout through the eye to the groin, this stripe very narrow on the head, broadening out behind the tympanum until it equals the greatest diameter of the latter, narrowing again on the sides of the body to disappear in the lumbar region; dorsal surface slightly stippled with the same brown tone; two pale streaks on either side of the back, extending from the eye to the pelvic region, free of this dark stippling; jaws and ventral surface immaculate; hinder and upper portion of the thigh indistinctly stippled with dark brown; upper surfaces of the lower limbs stippled with the same dark tone, the stippling tending to form three or more dark cross-bands. In life, the ground tone was a bright yellow and the pattern was much more distinct.

MEASUREMENTS

Tip of Snout to Vent	16.5	mm.
Tip of Snout to Posterior Border of Tympanum	5.8	"
Greatest Breadth of the Head	5.5	"
Distance from Axilla to Tip of Longest Finger	11.0	"
Distance from Vent to Tip of Longest Toe	26.0	"
Tibia	7.5	"

REMARKS

This distinctive species of *Hyloxalus* is of special interest because it seems to bridge the gap supposed to exist between *Hyloxalus* and *Phyllobates.* The species agrees entirely with *Phyllobates* in regard to its skeletal characters, and in most external features is similar to that genus, but the presence of the short web, much shorter than in any hitherto described species of *Hyloxalus,* prevents our referring it to *Phyllobates.* Undoubtedly, *Hyloxalus* is the more primitive genus, and it would be interesting to find the stock from which it arose. As I have pointed out elsewhere (Noble, 1922, Bull. A.M.N.H., Vol. XLVI, pp. 1-87), the brachycephalids have been derived from bufonid ancestors. It is highly probable that the stock from which *Hyloxalus* has been derived will be found in the *Bufonidae.*

The type specimen described above, although only 16.5 mm. in total length, possessed seven eggs within the ovaries, averaging 2 mm. in diameter. These eggs were heavily pigmented. All Salientia which lay eggs of such enormous size deposit them on land. It is therefore very probable that *Hyloxalus,* in spite of the web between its toes, is purely terrestrial and lays its eggs in moist situations similar to those utilized by *Eleutherodactylus.*

Hyla ornatissima sp. nov.

DIAGNOSIS

A medium sized *Hyla* possessing arched vomerine teeth which form a shallow ∩; fingers two-thirds webbed, toes nearly

entire webbed. Tibiotarsal articulation extending beyond the snout. Gaudy coloration of pinks and browns; two dark, pink-edged spots on the snout; a dark interorbital bar and a diamond shaped spot just anterior to the pelvis, similarly edged with pink.

TYPE

A.M.N.H. No. A-13491; adult ♀; Meamu, Mazaruni R., British Guiana; June 10, 1920; William Beebe.

DESCRIPTION OF TYPE

Tongue as long as broad, unemarginate behind; vomerine teeth in two slightly arched series nearly in contact with each other and directed slightly forward; the anterior margin of the arch on a level with the posterior border of the choanae. Head exactly as long as broad; nostrils near the end of the snout; interorbital space slightly more than half as great as the distance between nostril and eye; head greatly flattened with concave loreal region and prominent snout; interorbital space twice the diameter of the upper eye-lid, slightly greater than the greatest diameter of the eye; no ossification in the derm of the head; tympanum distinct, its greatest diameter less than half the greatest diameter of the eye. Tibiotarsal articulation extending beyond the tip of the snout. Digits with well-defined discs, these a trifle less than the greatest diameter of the tympanum; fingers two-thirds webbed; toes fully webbed, except that the web hardly extends beyond the base of the penultimate phalanx of the fourth toe; no external evidence of a rudiment of the prepollex. Skin smooth above, slightly granular on the belly; no folds on the back or sides of the body.

Ground color, in preserved specimens, pale straw-color or yellowish; dorsal surface finely sprinkled with small pink spots; a dark brown spot on either side of the snout edged with pink; a dark spot on each upper eye-lid and an interorbital bar of the same color, these outlined by the same pinkish tone; a dark diamond-shaped figure just anterior to the pelvis, continued posteriorly in a narrow coccygeal stripe; two small spots anterior to the diamond-shaped figure of the same tone, this figure broadly edged with pink, a few irregular pink blotches along the coccy-

geal stripe and near the anterior spots; tips of the toes brownish; two dark spots on the forearm; a few small pinkish spots on the upper surface of the limbs; a few small pinkish spots and three or four dark ones on the upper surface of the hind limbs; ventral surface immaculate except for the tips of the fingers and toes which are brownish.

MEASUREMENTS

Tip of Snout to Vent	40.0	mm.
Tip of Snout to Posterior Border of Tympanum	12.5	"
Greatest Breadth of the Head	14.0	"
Distance from Axilla to Tip of Longest Finger	22.5	"
Distance from Vent to Tip of Longest toe	70.0	"
Tibia	23.0	"

REMARKS

The species is represented in the collection by only a single specimen which was captured by an Indian and brought to the Zoological Station. Its gaudy coloration in life readily distinguishes it from the other Guianan hylas.

Leptodactylus stictigularis sp. nov.

DIAGNOSIS

A medium sized *Leptodactylus*, having a broad head; chestnut or reddish brown dorsal coloration; conspicuous whitish or pink upper lip and a dark throat studded with white spots. Tibiotarsal articulation extending to the middle of the eye; toes bearing narrow dermal fringes; skin smooth or granular; two well-defined dorso-lateral folds extending from eye to groin.

TYPE

A.M.N.H. No. A-10398; adult ♂; Kartabo, British Guiana; 1919; William Beebe.

DESCRIPTION OF TYPE

Size moderate; head flattened, a little broader than long; snout distinctly longer than the greatest diameter of the eye; dis-

tance between tip of snout and nostril contained twice in the distance between nostril and eye; interorbital space one and one-third times as broad as the upper eye-lid, about equal to the greatest diameter of the eye; canthus rostralis rounded but rather distinct; the loreal region concave; tympanum two-thirds the greatest diameter of the eye, separated from the eye by a space equal to half its own diameter. Tibiotarsal joints of either side overlap when the legs are placed at right angles to the body; tibiotarsal articulation, when extended forward, marks the middle of the eye. Digits slender, terminating in very small discs; first finger very long; second finger only two-thirds as long as the first; toes slender, bordered with a narrow fringe; sub-articular tubercles pronounced; two metatarsal tubercles, the outer two-thirds the length of the inner; a well-defined tarsal fold. Tongue large, slightly nicked behind; vomerine teeth in two arched groups nearly in contact with each other and touching the posterior border of the choanae; the most anterior part of each arch anterior to the posterior edge of the choanae. Skin smooth or slightly granular; a well-defined dorso-lateral fold extending from the eye to groin; ventral surfaces smooth, no abdominal disc.

Ground tone chestnut brown; upper lips broadly edged with gray; a grayish interorbital bar; the canthus and the dorso-lateral fold edged with dark brown; the supra-tympanic fold of the same color; posterior surfaces of thighs very dark brown; three or four rows of irregular whitish spots studding this dark area; three ill-defined dark bars on the dorsal surface of the thighs, three or four on the lower limbs; soles of feet very dark brown, parts of the lower leg suffused with the same color; sides of the body milky, stippled with the chestnut ground tone; ground tone of ventral surface white; throat a dark brown studded with numerous white spots; periphery of abdomen densely stippled with brown; middle of abdomen and distal portions of the thighs lightly stippled with the same color.

MEASUREMENTS

Tip of Snout to Vent	56.0	mm.
Tip of Snout to Posterior Border of Tympanum	20.5	"

Greatest Breadth of Head	23.0	"
Distance from Axilla to Tip of Longest Finger	34.0	"
Distance from Vent to Tip of Longest Toe	84.0	"
Tibia	27.0	"

REMARKS

The species is represented in our collections by a single paratype. It differs but little from the type in color. The dark throat color is indistinctly continued on the anterior part of the abdomen, but here the white spots have given place to white blotches. The pale stripe on the upper lip is pink in this specimen, and the interorbital bar is of the same color.

L. stictigularis seems to be most closely allied to *L. rhodomystax* Boulenger, from which it differs in its longer leg, somewhat differently arranged vomerine teeth and different coloration. *L. rhodomystax* has been recorded from British Guiana by Ruthven (1919 Occ. Papers Mus. Zool., Univ. of Mich., No. 69, p. 4.) I have recently had the opportunity of examining Ruthven's specimens and find them to be unquestionably the young of *L. pentadactylus.* This leaves the question open as to whether or not *L. rhodomystax* might not have been based upon a juvenile specimen of that species. This question can only be answered by examination of the types.

Leptodactylus minutus sp. nov.

DIAGNOSIS

A minute *Leptodactylus* lacking fringes to the toes and without dorsal folds; skin glandular, but never warty; an irregular series of dark spots above, these sometimes forming an interorbital bar and a symmetrical pattern on the shoulders. Apparently closely allied to *L. pulcher* Boulenger, from which it is distinguished by its different color pattern and shorter leg; somewhat similar to the immature *L. caliginosus* and *L. typhonius,* distinguished from these by the characters already mentioned.

TYPE

A.M.N.H. No. A-13495; adult ♀; Bartica District, British Guiana; January 8, 1916; William Beebe.

DESCRIPTION OF TYPE

Size very small; head distinctly longer than broad; distance between tip of snout and nostril contained twice in distance between nostril and eye; interorbital width one and one-half times as broad as the upper eye-lid, equal to the greatest diameter of the eye; canthus rostralis rounded, the loreal region sloping gradually; tympanum very distinct, one-half the greatest diameter of the eye, separated from the eye by a trifle less than half its own diameter. Tibiotarsal joints of each side strongly overlap when the legs are placed at right angles to the body; tibiotarsal articulations mark the anterior corner of the eye when the legs are extended forward. Tips of digits not swollen into discs, only slightly larger than the diameter of the penultimate phalanges; first finger a trifle shorter than the second; toes slender, not fringed; subarticular tubercles pronounced; two well-defined metatarsal tubercles; a tarsal fold. Tongue ovoid, slightly nicked behind; vomerine teeth in two slightly arched series well behind the choanae, separated from each other by a space equal to their distance from the choanae. Skin slightly glandular but not warty above, a few feeble warts on the sides of the body tending to form an ill-defined dorso-lateral fold; ventral surface smooth, a very pronounced abdominal disc.

Ground tone of dorsal surface dull olive-gray; three pale stripes running the length of the back, the two outer pale stripes irregularly suffused with pink; the whole dorsal surface, excepting the pale bands, irregularly spotted with dark brown; about twelve spots on the back and four on each side of the body ventral to the pale streak; two or three dark spots on each upper jaw; a series of dark spots forming cross bars on the limbs; hinder surface of thighs suffused with brownish; ventral surfaces immaculate excepting for a delicate suffusion of brown on the throat and hind limbs.

MEASUREMENTS

Tip of Snout to Vent	22.0 mm.
Tip of Snout to Posterior Border of Tympanum	8.0 "
Greatest Breadth of Head	7.5 "
Distance from Axilla to Tip of Longest Finger	12.5 "
Distance from Vent to Tip of Longest Toe	37.0 "
Tibia	11.0 "

REMARKS

The six paratypes show a considerable range of variation in color; the ground tone may be very pale or somewhat darker than in the type; a well-defined interorbital bar may be present forming a regular cross with a scapular marking; the other spots on the back may have a very symmetrical or irregular arrangement; the dark spots on the upper jaw usually form a very well-defined series; the three dorsal stripes are not as well-defined in the paratypes as in the type; in three of the specimens there is no indication of these light streaks.

Leptodactylus rugosus sp. nov.

DIAGNOSIS

A small species, very similar to *L. caliginosus,* but with a broader head, shorter leg and very rugose dorsum. It is further distinguished from that species by its large tympanum, different coloration, and absence of nuptial spines in the breeding male.

TYPE

A.M.N.H. No. A-1169; adult ♂; near Kaieteur Falls, British Guiana; August 13, 1911; F. E. Lutz.

DESCRIPTION OF TYPE

Size small; head flattened, as long as broad; snout longer than the greatest diameter of the orbit; interorbital space narrower than the breadth of the upper eye-lid, much less than the greatest diameter of the eye; canthus rostralis rounded; loreal

region slightly concave; tympanum two-thirds the greatest diameter of the eye, separated from the latter by a space less than half its own diameter. Tibiotarsal joints of either side barely overlap when the legs are placed at right angles to the body; tibiotarsal articulation when extended forward reaches the anterior border of the tympanum. Digits slender, without terminal dilations; first finger longer than the second; toes slender, without fringes; subarticular tubercles pronounced; two metatarsal tubercles, the outer two-thirds the length of the inner; a well-defined tarsal fold. Tongue large, slightly nicked behind; vomerine teeth in two arched series on a level with the posterior border of the choanae, and nearly in contact with each other in the mid-line; anterior edge of each arch not extending forward beyond the choanae. Skin very rugose above, some of the tubercles forming short folds which run cephalo-caudad on the back; upper eye-lids covered with numerous warts; a few warts on the snout and dorsal surface of the limbs.

Ground tone above reddish brown, a few indistinct paler marks on the upper lip, and numerous pale mottlings on the posterior surfaces of the thighs; some indication of dark cross-bands on the upper and lower legs; ventral surfaces straw-colored, heavily blotched with brown, the spotting darkest on the throat and palest on the ventral surfaces of the thighs.

MEASUREMENTS

Tip of Snout to Vent	38.0	mm.
Tip of Snout to Postrior Border of Tympanum	15.5	"
Greatest Breadth of Head	16.0	"
Distance from Axilla to Tip of Longest Finger	21.5	"
Distance from Vent to Tip of Longest Toe	55.0	"
Tibia	17.5	"

REMARKS

The four paratypes in our collection range from 16.5 to 41.0 mm. head and body length. They show very little variation

in either coloration or structural characters. The pale bars on the upper lip are very distinct in the largest specimen and some indication of an interorbital bar is present. The venter of all four paratypes is either immaculate or lightly spotted with brown.

Volume III, Number 15

NEW LIZARDS
FROM THE TROPICAL RESEARCH STATION BRITISH GUIANA

By G. KINGSLEY NOBLE
Associate Curator of Herpetology, in Charge,
American Museum of Natural History

Among the reptiles secured by Mr. William Beebe or by his staff at the New York Zoological Society's Tropical Research Station in British Guiana, there are included a number of rare and interesting forms. Two lizards in the collection are found to be undescribed, while two others are reported from British Guiana for the first time. The latter are *Neusticurus bicarinatus* (Linné), from Kartabo, and *Cercosaura ocellata* Wagler from both Kartabo and the Bartica District. Many of the species secured by Mr. Beebe, such as *Sphaerodactylus molei* Boettger, were very imperfectly known. These Mr. Beebe is planning to discuss in a later paper. The present paper is limited to merely a description of the new forms in the collection. It may be added that the species described below will be figured in Mr. Beebe's general account of the reptiles of the Research Station.

Gonatodes beebei sp. nov.

DIAGNOSIS

A large *Gonatodes* of uniform reddish brown color above and without spots on the throat or venter; a species having not one but a series of spines over the eye, and having the nostril not indenting the rostral.

TYPE

A.M.N.H. No. R-21251; adult ♂; Kartabo, British Guiana; 1921; William Beebe.

DESCRIPTION OF TYPE

Size large; distance from tip of snout to ear contained exactly four times in the distance from snout to vent; greatest diameter of the eye contained one and one-half times in the

* Tropical Research Station, Contribution Number 135.

distance from tip of snout to eye; distance from tip of snout to nostril contained twice in the distance between nostril and eye; distance from snout to middle of eye decidedly greater than the distance from ear to latter point; ear opening oval in outline, about one-third the greatest diameter of the eye. Digits cylindrical, proximal scales of their ventral surfaces very much larger than distal ones, grading rather abruptly into the latter; dorsal surfaces of head and body covered with coarse granules, those of the head not larger than those of the body; granules of the occiput slightly smaller than those of the snout; posterior superciliaries slightly more pointed but not distinctly larger than the supraorbitals; anterior superciliaries very much larger than the supraorbital granules, three or four of these enlarged superciliaries sharply pointed and forming a series of low spines which project from the upper eye-lid just anterior to the mid point of the eye; a large cleft rostral bordered posteriorly by three small median granules, two large lateral scales and the nostrils; nostrils in contact with the rostral but not indenting it; five upper and four lower labials; mental large, pointed behind, followed by two small scales larger than the smallest labial, gular region with coarse granules of the same size as those of the snout; ventral surfaces of the body and posterior appendages covered with large cycloid, overlapping scales, these of about three times the diameter of the dorsal granules; under surface of the tail covered proximally with scales similar to those of the abdomen, covered distally by one or two series of very broad scales,—these scales three to five times as broad as the abdominal scales.

Uniform reddish brown above, whitish immaculate below, except for a slight suffusion of brown on the abdomen and appendages, this suffusion tending to form dark edges to the scales of the ventral surface of the thigh.

MEASUREMENTS

Tip of Snout to Vent	47.0	mm.
Tip of Snout to Ear	11.5	"
Tip of Snout to Orbit	5.5	"
Greatest Width of Head	7.0	"
Vent to Tip of Tail	47.0	"

REMARKS

The species is represented in our collections by only a single specimen. The species may be readily distinguished from other forms of *Gonatodes* by its large size, narrow head and uniform coloration. It is perhaps allied to *G. ferrugineus* described by Cope from Trinidad.

Leposoma taeniata sp. nov.

DIAGNOSIS

Very closely related to *L. scincoides* and *L. dispar;* intermediate between these two forms in scutation, very different from either in coloration; fronto-nasal obtusely angular posteriorly; one anterior and three pairs of chin shields, the posterior pair separated from each other by a single scale; scales of the body strongly keeled, mucronate; dorsal scales forming transverse and oblique rows; ventral scales forming transverse and longitudinal rows on the abdomen. Reddish brown above, whitish below, a broad band of dark brown extending along either side of the head and body.

TYPE

A.M.N.H. No. R-21266; adult ♀; Kartabo, British Guiana; June 19, 1919; William Beebe.

DESCRIPTION OF TYPE

Head narrow; fronto-nasal obliquely angular behind; a pair of small prefrontals, not half as long as the frontal, slightly larger than the fronto-parietals; two lateral parietals and an enormous inter-parietal, the former about one-third as wide as the latter; four supraoculars; all dorsal head shields roughened, as in the other species of *Leposoma;* no loreal but two freno-orbitals, the dorsal having twice the diameter of the ventral; six upper and five lower labials; chin shields large, one anterior and three pairs, the two anterior pairs in contact, the posterior pair separated by a single scale; a few enlarged scales posterior to the chin shields; separated from the gulars by a single row of small scales which extends across the throat from ear to

ear; chin shields similar to the ventrals, but narrower and more pointed. Body covered with uniform scales which form transverse and oblique rows on the back, transverse and longitudinal rows on the ventral surface; the scales about as broad as they are long; strongly keeled, mucronate; 27 scales around the middle of the body, 38 scales from the occiput to the base of the tail and 40 from the third pair of chin shields to the vent; 4 pre-anals, three of these slightly larger than the ventral scales; caudal scales like those of the body but the scales tending to form regular longitudinal and transverse rows as on the venter; the keels of the caudal scales forming a series of ridges; 14 of these ridges around the tail, fifteen scales from the base.

Ground tone above, reddish brown, two broad stripes of dark brown extending from the tip of the snout along the entire length of head and body and about one-third the length of the tail; no spotting on dorsal surface; a few dark spots on the labials and sides of the head; sides of the body below dark stripe, brownish, somewhat spotted; ventral surface white, immaculate except for four small spots on the chin shields and a suffusion of brown on the ventral surface of the tail.

MEASUREMENTS

Tip of Snout to Vent	34.0 mm.
Tip of Snout to Ear	7.5 "
Tip of Snout to Orbit	3.0 "
Greatest Width of Head	4.5 "

REMARKS.

The eight paratypes of this species in the collection differ only slightly in color. They all exhibit the dark band on either side of the head and body. In a few specimens there is some indication of a pale, narrow band dorsal to this dark stripe. In a few of the specimens there are a few flecks of dark brown on the dorsal surface, but these never form the dark spots found in the other species of the genus. This flecking is perhaps most distinct at the base of the tail.

There is very little variation in scutation. The scale counts of six of the paratypes (two others are badly damaged) is as follows:

Scales around the middle of the body average............27.0
(Max. 29. Min. 26.)
Scales from occiput to base of tail average............38.2
(Max. 39. Min. 37.)
Scales from 3d pair of chin shield to vent average 39.6
(Max. 40. Min. 39.)

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III, NUMBERS 16-21

(Tropical Research Station Contributions 136-141)

PUBLISHED BY THE SOCIETY

THE ZOOLOGICAL PARK, NEW YORK

OCTOBER 1, 1923

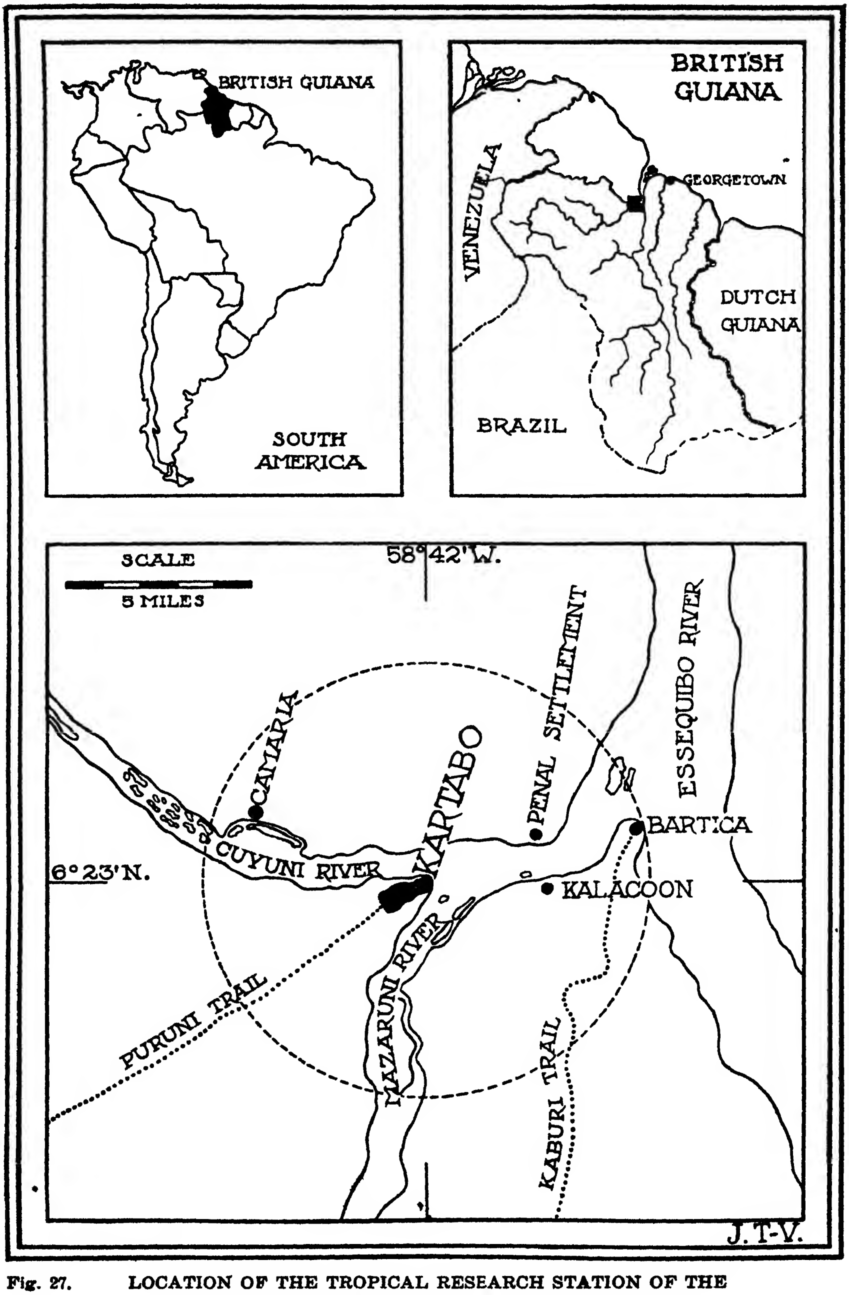


Fig. 27. LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

First form on press October 16, 1923

DESCRIPTIONES TERMITUM IN ANGLORUM GUIANA REPERTORUM*

By F. SILVESTRI.

(Plates XI-XV).

Eutermes parvellus

(Plate XI).

Femina alata.—Corpus castaneum clypeo isabellino, pronoto macula isabellina T-formi signato, mesonoti et metanoti parte antica isabellina, sternorum 1-6 parte mediana isabellina, pedibus rufescentibus, alis rufo-brunis.

Caput fere 1/4 longius quam inter oculos latius, supra setis sat numerosis brevibus et brevioribus instructum, fenestra perparva angustiore cum linea antica, clypeo bene inflato sat setoso, ejusdem dimidia parte c. 1/5 latiore quam longiore; oculis sat magnis, bene convexis, prominulis, ocellis parvis, ab oculis aliquantum minus quam ocelli diametros longitudinalis remotis, antennis 14-articulatis, articulo tertio quam secundus fere dimidio breviore et quam quartus parum longiore.

Pronotum subsemiellipticum, quam caput cum oculis 1/3 minus latum, medium antice haud sinuatum, spatio brevissimo sursum vergente, lateribus gradatim convergentibus, margine postico rotundato; meso- et metanotum lateribus gradatim aliquantum convergentibus, angulis posticis rotundatis, margine postico medio parum late et parum profunde inciso. Alae in superficie tuberculis percrebris 5-6 radiatis et setis brevibus sparsis instructa; venas vide Plate XI, 4, 5.

Pedes bene setosi; tibiae secundi paris setas vide Plate XI, 7.

Abdominis tergita et sternita setis numerosis brevibus et brevioribus, pleuris setis brevioribus sat numerosis instructis. Cerci breviores setas vide Plate XI, 8.

* Tropical Research Station, Contribution No. 136.

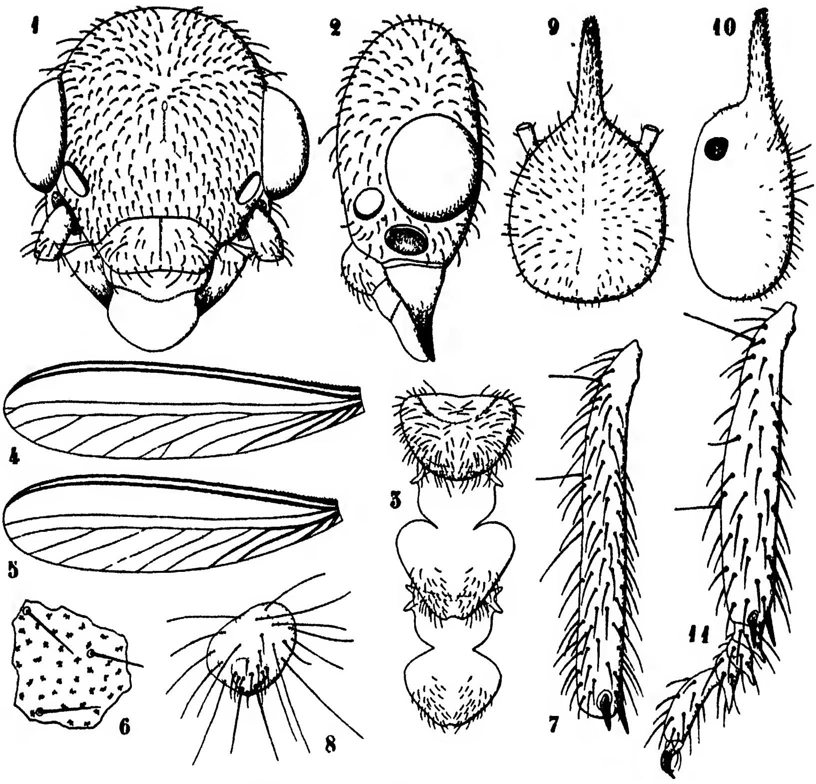


Plate XI. *EUTERMES PARVELLUS.*

1, feminae caput pronum; 2, idem lateraliter inspectum; 3, scuta thoracalia; 4, 5, alae; 6, alae particula multo ampliata; 7, tibia pedum paris secundi; 8, cercus; 9, 10, militis caput pronum et lateraliter inspectum; 11, militis pes paris secundi a tibia.

Long. corp. cum alis mm 8, sine alis 5, long. capitis 0,65, ejusdem lat. inter oculos 0,52, diametros longitud. oculi 0,28, long. antennarum 1,20, alae anticae 6,7, ejusdem lat. 1,7, long. tibiae III, 0, 78.

Mas. Feminae similis.

Miles. Corpus stramineum abdomine cibi contenti causa maxima pro parte cinereo.

Caput (Plate XI, 9-10) parum minus quam duplo longius quam latius, subovale, naso sat longo et sat attenuato, superficie setis brevioribus sat numerosis et setis nonnullis brevibus

instructa, antennis 12-articulatis, articulo tertio quam secundus multo angustiore et c. 1/3 breviore, a quarto haud bene separato et quam idem aliquantum angustiore et eidem longitudine subaequali.

Pronoti lobus anticus parvus, margine medio paullum profunde sinuato, antice setis nonnullis spiniformibus instructus, postice setis 3+3 sat longis et nonnullis brevioribus; meso- et metanotum parce setosa lateribus rotundatis.

Pedes sat setosi; secundi paris vide Plate XI, 11, tarsorum articulis 1-3 apice infero elongato, acuto.

Abdominis tergita et sternita setis sat numeroris brevioribus et brevibus instructa. Cerci apice acuto instructi.

Long. corporis mm. 2,5, long. capitis 0,98-1,04, ejusdem lat. 0,56, long. nasi ab antennarum foveae margine antico mensi 0,39, antennarum 0,90, tibiae III, 0,52.

Operarius militi similis capite aeque longo atque lato, antennis 13-articulatis, articulo tertio a quarto vix distincto et quam secundus angustiore et c. dimidio breviore.

Long. corp. mm. 2,8-3, lat. capitis 0,58, long. antennarum 0,78, tibiae III, 0,38.

Observatio. Species haec ad *Eutermes microsoma* Silv. perproximum sed imaginis oculis parum majoribus et magis prominentibus, militum capite, praesertim naso, breviore facile distinguenda est; ab *Eutermes holmgreni* Banks militis capitis latitudine etiam distincta.

Habitat. Anglorum Guiana: Exempla vidi alata, nec non milites et operarios apud Kartabo cl. A. Emerson collecta, et milites et operarios cl. G. E. Bodkin lecta.

Hamitermes excellens sp. nov.

(Plate XII).

Femina alata. Corpus supra brunum clypeo latericio, ore et abdominis tergito ultimo rufescentibus, urosternitis lateraliter brunis, cetera superficie pallide isabellina, pedibus rufescentibus, alis brunis.

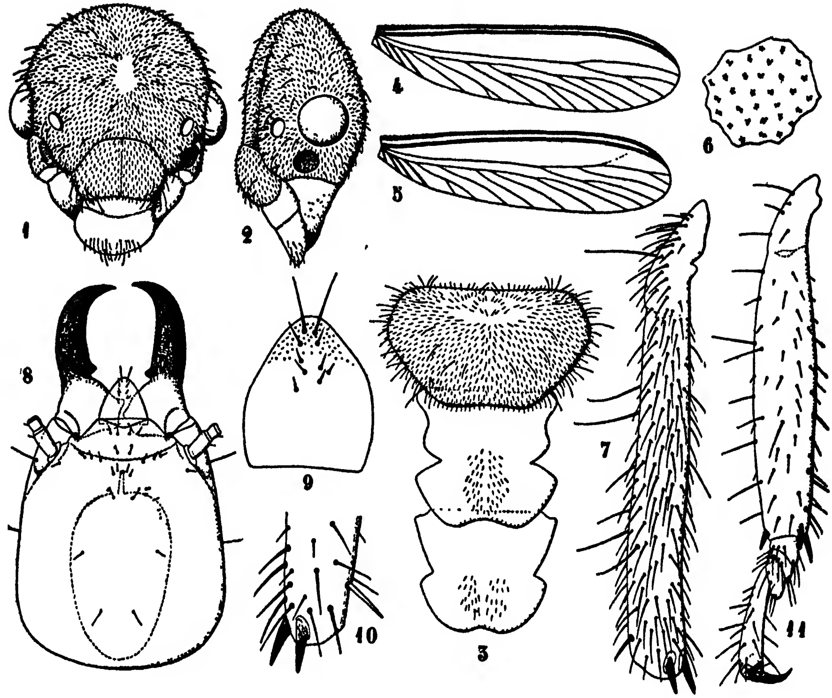


Plate XII. *HAMITERMES EXCELLENS* SP. NOV.

1, feminae caput pronum; 2, idem lateraliter inspectum; 3, scuta thoracalia; 4, 5, alae; 6, alae particula; 7, tibia paris secundi; 8, militis caput pronum; 9, ejusdem labrum; 10, militis tibia secundi paris postice inspecta; 11, militis pes primi paris a tibia.

Caput paullum longius atque inter oculos latius, supra setis brevibus et brevioribus numerosis instructum, fenestra magna subovali, parum longiore quam latiore, clypeo bene inflato et bene setoso, ejusdem dimidia parte c. 1/4 longiore quam latiore; oculis sat magnis, convexis, prominulis, ocellis parvis, ab oculis quam ocelli diametros longitudinalis parum minus remotis, antennis 15-articulatis, articulo tertio quam secundus c. dimidio et quam quartus c. 1/3 breviore, articulo quarto quam quintus parum longiore.

Pronotum quam caput cum oculis parum minus latum, medium antice haud sinuatum, brevi spatio sursum vergens lateribus parum longe ab angulo antico multo convergentibus margine postico subrecto, meso- et metanotum lateribus ali-

quantum convergentibus, margine postico medio late et parum profunde sinuato, angulis posticis rotundatis.

Alae superficie setis brevioribus sparsis et aliis per venas dispositis et tuberculis percrebis 5-6 radiatis instructa; venas vide Plate XII, 4, 5.

Pedes bene setosi, secundi paris tibiis, praeter calcaria duo interna, seta spiniformi parum robusta praeapicali externe aucta.

Abdominis tergita et sternita setis pernumerosis brevioribus et setis brevibus instructa. Cerci breviores, bene setosi.

Long. corp. cum alis mm 12, sine alis 6,8, long. capitis 1,23, ejusdem lat. inter oculos 1,17, diametros long. oculi 0,39, long. antennarum 1,68, alae anticae 10,2, ejusdem lat. 2,7, long. tibiae III, 1,38.

Mas feminae similis.

Miles. Corpus cremeum vel ochroleucum capite ferrugineo, mandibulis parte distali nigrescente, abdomine cibi contenti causa cinereo.

Caput parum longius quam latius, late convexum, lateribus partem anticam versus parum convergentibus, angulis posticis rotundatis, superficie supera setis paucis instructa, fontanella labro subsemielliptico, paullum longiore quam ante basim latiore, basi ipsa parum angustiore, setas vide Plate XII, 8, mandibulis quam capitis latitudo aliquantum brevioribus, dente sat magno ad basim partis distalis instructis, parte apicali bene arcuata, attenuata, antennis 15-articulatis, articulo tertio quam secundus et quam quartus 1/3 breviore, articulo quarto quam quintus parum breviore, in antenna nonnulla a tertio haud bene separato.

Pronotum quam capitis latitudo c. dimidio minus latum, lobo antico sursum vergente, medio parum sinuato, margine postico subrecto, lateribus rotundatis, superficie supera setis nonnullis sat longis et brevibus instructa, lobi antici superficie antica setis nonnullis brevissimis sat robusti instructa; meso- et metanotum lateribus rotundatis, supra setis nonnullis sat longis et brevibus praesertim posticis instructa.

Pedes sparse setosi, primi paris tibiis setis nonnullis internis robustis, secundi paris tibiis etiam seta spiniformi attenuata externa instructa.

Abdominis tergita et sternita setis sat longis sat numerosis et setis nonnullis brevibus et brevioribus instructa. Cerci articulo secundo quam primus c. 1/3 longiore, conico, acuto, setis consuetis.

Long. corp. (cum mandibulis) mm 6, long. capitis (sine mandibulis) 2,10, ejusdem lat. 1,76, long. antennarum 2, mandibularum 1,28, tibiae III, 1, 32.

Operarius. Corpus cremeum capite ochroleuco, abdomine cibi contenti causa cinereo.

Caput fere 1/9 latius quam longius, supra setis sat longis et brevibus instructum, clypeo sat inflato ejusdem dimidia parte paullum longiore quam latiore, antennis 15-articulatis, articulo tertio quam secundus c. dimidio et quam quartus parum breviore.

Thorax et abdomen eisdem militis similia.

Long. corp. mm 5, long. capitis 1,10, ejusdem lat. 1,8, long. antennarum 1,30, tibiae III, 1,10.

Habitat. Anglorum Guiana: exempla alata et militem et operarium ad Kartabo (ab A. Emerson) lecta et exempla alia ad Potaro a Bodkin vidi.

Observatio. Species haec magnitudine et militis forma ab *Ham. hamifer* Silv. distinctissima est.

Capritermes bodkini sp. nov.

(Plate XIII.)

Nympha feminilis. Corpus stramineum.

Caput aliquantum longius quam inter oculos latius, supra setis paucis brevibus instructum, oculis parvis, fuscis, parum prominentibus, antennis 16-articulatis, articulo tertio divisionem proximalem vix distinctam monstrante, secundum longitudine aequante et quam quartus vix longiore.

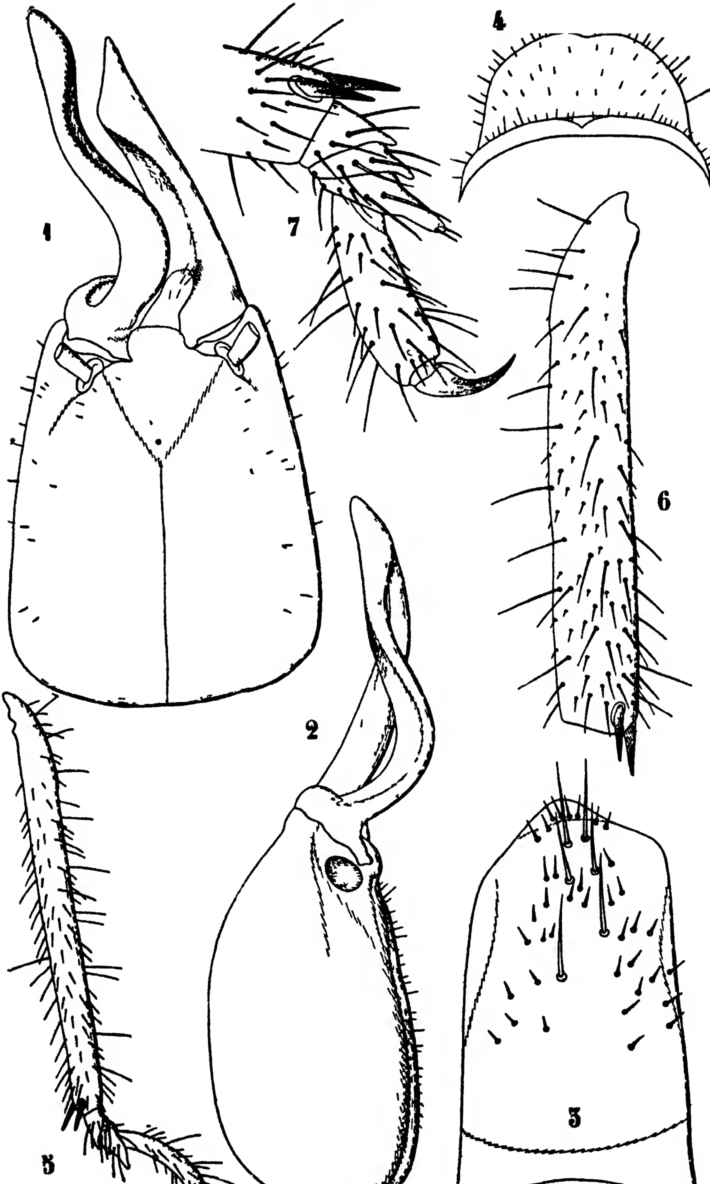


Plate XIII. *CAPRITERMES BODKINI* SP. NOV.

1, militis caput pronum; 2, idem lateraliter inspectum; 3, ejusdem labrum; 4, pronoti lobus anticus a facie postica inspectus; 5, pes paris secundi a tibia; 6, nymphae tibia primi paris; 7, nymphae pedis primi paris a tibia apex.

Pronotum quam caput cum oculis c. 1/5 minus latum, postice aliquantum late et parum profunde sinuatum. Appendices alares long. mm 2,4.

Pedes primi paris (Plate XIII, 7) ut ceteri calcaribus duobus instructi, parce setosi.

Long. corp. mm 8, long. capitis 1,62, ejusdem lat. inter oculos 1,35, long. antennarum 3, tibiae III, 2,2.

Miles. Corpus ochroleucum capite ochroleuco vel ochraceo mandibulis nigris. Caput fere 1/4 longius quam postice latius supra parce convexum lateribus partem posticam versus gradatim parum divergentibus, labro (Plate XIII, 3) subrectangulari apice subtriangulari, parum minus quam duplo longiore quam latiore, setis paucis brevibus distalibus et setis sat numerosis brevissimis instructo, mandibula laeva quam caput parum breviore, forma vide (Plate XIII, 1-2), mandibula dextera quam laeva aliquantum breviore, apice triangulari acuto, antennis 16-articulatis, articulo tertio secundum longitudine aequante et quam quartus paullum breviore.

Pronotum quam caput c. dimidio minus latum, lobo antico magno, margine supero medio parum inciso, facie antica setis brevissimis conicis sat numerosis, margine supero setis nonnullis brevibus et brevioribus, facie postica setis nonnullis brevioribus instructa; mesonotum postice subrotundatum, metanotum margine postico late et sat profunde sinuato.

Pedes longi, parce setosi, primi paris ut ceteri calcaribus duobus armati.

Abdominis tergita setis sat numerosis brevibus et sternita etiam setis sat numerosis brevioribus instructa. Cerci bene setosi, parte apicali longiuscula attenuata.

Long. corp. mm 11, long. capitis 3,8, ejusdem lat. 3, long. mandibulae laevae 3, antennarum 4,2, tibiae III, 3.

Operarius. Corpus ochroleucum, abdomine cibi contenti causa cinereo.

Caput subaeque longum atque latum, fenestra magna, setis nonnullis brevioribus instructum, clypeo bene inflato, antennis

16-articulatis articulo tertio nudo a quarto haud bene separato, quam secundus 1/3 breviore et quartum longitudine subaequante.

Thorax et abdomen eisdem militis similia.

Long. corp. mm 5,5, long. capitis 1,35, long. antennarum 2,20, tibiae III, 2.

Habitat. Anglorum Guiana: Potaro River (Bodkin legit. Dec., 1915).

Observatio. Species haec pedibus primi paris calcaribus duobus tantum instructis, militis capitis et labri forma, pedum longitudine distinctissima est.

Capritermes bodkini **Silv.** ***modestior*** var. nov.

(Plate XIV.)

Femina alata. Caput et thoracis tergita luride testacea, clypeo aliquantum pallidiore, abdominis tergita rufescentia, sternita ochraceo-ferruginea, pedibus testaceo rufescentibus, alis? (in exemplo typico abruptis).

Caput parum longius (c. 1/11) quam inter oculos latius, supra setis sat numerosis minimis et nonnullis brevibus, fenestra magna, obcordiformi, bruna, prominula, clypeo parum inflato transverse subrectangulari ejusdem dimidia parte aliquantum latiore quam longiore; oculis sat magnis, bene convexis, ocellis sat parvis ab oculis ocelli dimidia longitudine distantibus, antennis ?-articulatis (in exemplo typico haud integris, articulis 12-sistentibus), articulo tertio secundo subaequali et quam quartus paullum longiore.

Pronotum quam caput cum oculis aliquantum minus latum, parum magis quam duplo latius quam longius, medium antice vix sinuatum, brevi spatio sursum vergente, angulis anticis late rotundatis, lateribus aliquantum convergentibus, angulis posticis late rotundatis, margine postico late et parum profunde sinuato; meso- et metanotum lateribus postice aliquantum convergentibus, margine postico parum late et aliquantum profunde sinuato, angulis posticis obtusis.

Alae? (abruptae).

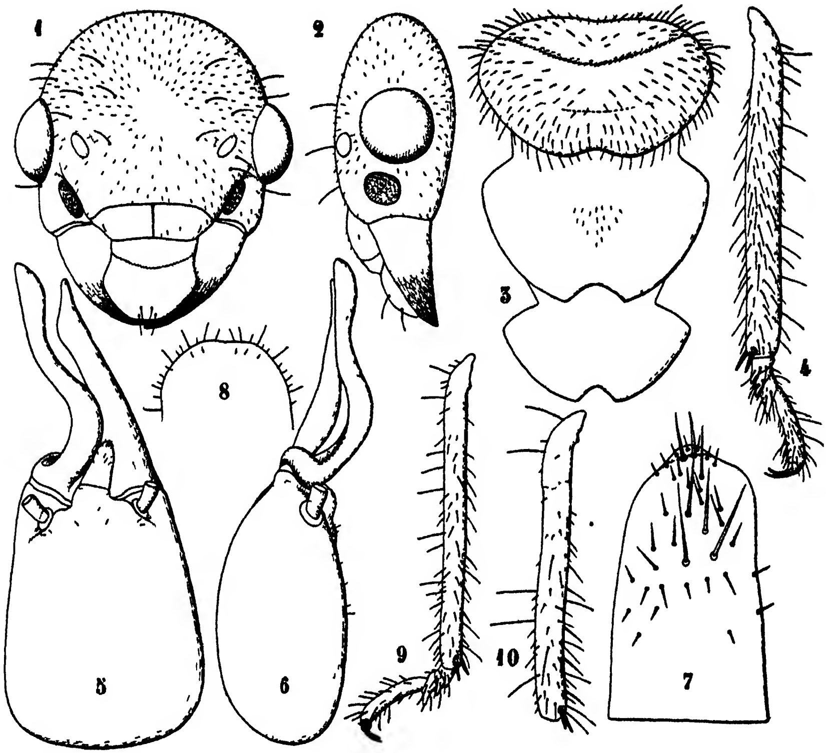


Plate XIV. *CAPRITERMES BODKINI* SILV. *MODESTIOR* VAR. NOV.

1, feminae caput pronum; 2, idem lateraliter inspectum; 3, scuta thoracalia; 4, pes paris secundi a tibia; 5, militis caput pronum; 6, idem lateraliter inspectum; 7, ejusdem labrum; 8, militis pronoti lobus anticus postice inspectus; 9, militis pes secundi paris a tibia; 10, operarii tibia primi paris.

Pedes bene setosi, tibiae setis internis sat robustis.

Abdominis tergita et sternita setis pernumerosis brevioribus et setis brevibus nonnullis instructa. Cerci breviores, bene setosi.

Long. corp. cum alis ?, sine alis 9, long. capitis 1,70, ejusdem lat. inter oculos 1,56, diametros long. oculi 0,59, long. antennarum ? , alae anticae ? , ejusdem lat. ? , long. tibiae III, 2.

Miles. Corpus stramineum, capite cremeo, mandibulis nigris.

Caput 1/6 longius quam postice latius, supra parce convexum, lateribus a parte antica ad posticam aliquantum divergentibus, labro subrectangulari, apice tantum subtriangulari parum minus quam duplo longiore quam postice latiore, parte distali supra setis nonnullis brevioribus et aliis brevissimis instructa, mandibula laeva capitis longitudinem aequante, forma vide (Plate XIV, 5-6), mandibula dextera quam laeva aliquantum breviore apice triangulari, antennis 16-articulatis. articulo tertio quam secundus c. 1/4 breviore et quam quartus parum longiore.

Pronotum quam capite c. dimidio minus latum, lobo antico magno, margine supero late rotundato medio vix inciso, facie antica setis brevissimis conicis sat numerosis, margine supero setis nonnullis brevibus et brevioribus, facie postica setis nonnullis brevioribus instructa, mesonotum postice vix sinuatum, metanotum late et sat profunde sinuatum.

Pedes longi, parce setosi, secundi paris vide (Plate XIV, 9).

Abdominis tergita et sternita setis nonnullis brevibus et aliis parce numerosis brevioribus vel (in dorso) brevissimis instructa. Cerci apice subconico longiusculo.

Long. corp. mm 10, long. capitis (sine mandibulis) 3, ejusdem lat. 2,5, long. antennarum 3, 6, mandibulae laevae 3, tibiae III, 2,5.

Operarius. Corpus stramineum, abdomine cibi contenti causa cinereo.

Caput c. 1/6 longius quam latius, ad antennas latius, supra seta nonulla breviore instructo, clypeo bene inflato, ejusdem dimidia parte parum latiore quam longiore, antennis 15-articulatis, articulo tertio quam secundus aliquantum angustiore et parum breviore, quam articulus quartus haud longiore et parum angustiore.

Thorax et abdomen ejusdem militis similia.

Long. corp. mm 4, long. capitis 1, ejusdem lat. 1,24, long. antennarum 1,85, tibiae III, 2,4.

Habitat. Anglorum Guiana: exempla typica ex Kartabo ab A. Emerson lecta.

Syntermes parallelus sp. nov.

(Plate XV).

Femina alata. Corpus castaneum, capitis parte antica testacea, mandibulis praeter apicem nigrum testaceis, thoracis pleuris et sternitis testaceo-latericiis areis avellaneis interruptis, antennis pedibusque testaceis, alis fuligineis, abdominis ventre ochraceo.

Caput subaeque longum atque inter oculos latum, supra setis paucioribus sparsis instructum, fenestra magna, circulari, clypeo convexiusculo, ejusdem dimidia parte fere 1/5 latiore quam longiore, oculis sat parvis valde convexis, ocellis (capite prono) ab oculis quam oculi diametros longitudinalis parum minus distantibus, antennis 19-articulatis, articulo secundo quam tertius haud vel paullum breviore et quam quartus aliquantum longiore.

Pronotum quam caput cum oculis vix minus latum, medium antice paullum, postice aliquantum sinuatum, angulis anticis acutis haud productis, angulis posticis late rotundatis, meso- et metanotum postice lateribus parum convergentibus, mesonoti margine postico latissime, metanoti vix sinuato.

Alae superficie setis brevioribus numerosis vestita; venas vide Plate XV, 4-5.

Pedes setuloli, tibiae latere interno setis brevibus sat robustis numerosis instructo, calcaribus apicalibus elongatis.

Abdominis tergita setis nonnullis praesertim posticis, sternita setis numerosis brevioribus instructa.

Long. corp. cum alis mm 29, sine alis 17, long. capitis cum mandibulis 3,7, sine mandibulis (labro excluso) 2,8, ejusdem lat. inter oculos 2,6, diametros longitudinalis oculi 0,59, long. antennarum 5, alae anticae 24,5, ejusdem lat. 5,8, long. tibiae III, 4.

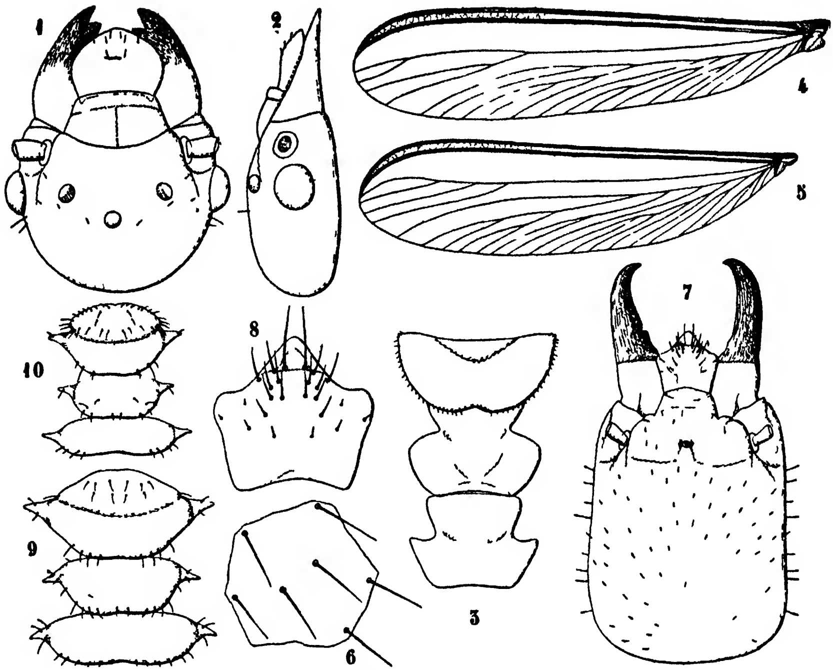


Plate XV. *SYNTERMES PARALLELUS* SP. NOV.

1, feminae caput pronum; 2, idem lateraliter inspectum; 3, scuta thoracalia; 4, 5, alae; 6, alae particula multo ampliata; 7, militis caput pronum; 8, ejusdem labrum; 9, militis scuta thoracalia; 10, operarii scuta thoracalia.

Mas ignotus.

Miles. Corpus fulvo-testaceum capite ochraceo-ferrugineo, mandibulis parte distali nigra.

Caput c. 1/3 longius quam latius lateribus parallelis, angulis posticis late rotundatis, setis brevioribus paucis sparsis instructum, supra pone fontanellam bene convexum, antice a fontanella ad labrum discendens et utrimque ad antennas aliquantum inflatum, fontanella supra tuberculum minimum tubiformem sita. Labrum (deplanatum) parum latius quam longius, antice angustatum, subtriangulare, utrimque ad partis triangularis basim excisum, lateribus ceteris postice parum convergentibus, setis vide (Plate XV). Mandibulae sat robustae, quam capitis latitudo c. 2/9 breviores, dextera dente minimo ad partis distalis basim, laeva a dente sat magno et dentibus

duobus minimis, praeter basalem, armata, parte distali attenuata, apice breviter arcuato, acuto. Antennae 19-articulatae, articulo secundo quam tertius vix et quam quartus aliquantum longiore, articulo decimo duplo latiore quam longiore.

Scuta thoracalia in processum lateralem brevem (metanoti mm 0,48) acutum, spiniformem, extrorsum et aliquantum sursum vergentem producta; pronoti lobus anticus margine medio vix sinuato.

Pedes longi, breviter setosi.

Abdomen tergitis setis paucis praesertim posticis, sternitis setis sat numerosis intructis.

Long. corp. mm 12, long. capitis cum mandibulis 6,8, sine mandibulis 4,5, antennarum 4,6, tibiae tertii paris 3, lat. metanoti cum spinis 2,5.

Operarius major. Corpus fulvo-testaceum antennis latericiis, abdomine cibi contenti causa fusco-cinereo. Caput subaeque longum (mandibulis exclusis) atque latum lateribus postice parum convergentibus, fenestra circulari manifesta, supra setis paucioribus sparsis instructum, clypeo subplano setis 3-4 instructo; antennis 19-articulatis, articulo secundo quam tertium haud vel vix breviore et quam quartus aliquantum longiore, articulo decimo magis quam duplo longiore quam latiore.

Scuta thoracalia in processum lateralem brevem (metanoti mm 0,20) acutum, spiniformem producta; lobus anticus margine medio vix sinuato.

Abdomen tergitis setis paucis praesertim posticis, sternitis setis sat numerosis intructis.

Long. corp. mm 8, lat. capitis 2,6, long. antennarum 6, tibiae paris tertii 2,6, metanoti lat. 2.

Operarius minor. Corpus ochroleucum, abdomine cibi contenti causa cinereo.

Caput parum latius quam (mandibulis exclusis) longius fenestra magna, antennis 18-articulatis, articulo secundo quam

tertius haud vel parum breviore et quam quartus paullum longiore.

Scuta thoracalia in processum lateralem perbrevem (metanoti mm 0,12) acutum producta.

Long. corp. mm 7, lat. capitis 1,9, long. antennarum 3,5, tibiae paris tertii 2, metanoti lat 1,56.

Habitat. Anglorum Guiana: Cattle Trail Survey, Canister Falls VI. 1920. A. A. Abraham legit.

Observatio. Species haec ad *S. molestus* Burm. proxima est, sed magnitudine majore, corporis et alarum colore, militis capitis forma et spinis thoracalibus bene distincta est.

NEW GENERA AND SPECIES OF TERMITOPHILOUS COLEOPTERA FROM NORTHERN SOUTH AMERICA*

By WILLIAM M. MANN.
Bureau of Entomology, Department of Agriculture, Washington, D. C.

(Figs. 28-40)

Mr. Alfred Emerson has had the kindness to loan me for study a most remarkable series of beetles that he collected in termite nests, chiefly at the Tropical Research Station at the New York Zoological Society at Kartabo, British Guiana, but containing also several species from Trinidad.

The present paper includes merely descriptions of some of the forms It is intended at a later date, to publish a more extended account of these, together with descriptions and notes of others.

Holotypes of the new species have been deposited in the U. S. National Museum collection.

The accompanying habitus drawings have been made by Mr. Robert E. Snodgrass, Mr. Harry B. Bradford and Miss Julia Ellen Edmonson.

Family—STAPHYLINIDAE
Subfamily—ALEOCHARINAE
Tribe—COROTOCINI

Spirachtha mirabilis sp. nov.

(Fig. 28)

Female.—Length 2-2.50 mm. Membranous portions white, in some of the larger specimens irregularly infuscated; chitin on abdomen and tarsi pale brown, on head and thorax darker brown, antennae and legs black. Feebly shining.

* Tropical Research Station, Contribution Number 137.

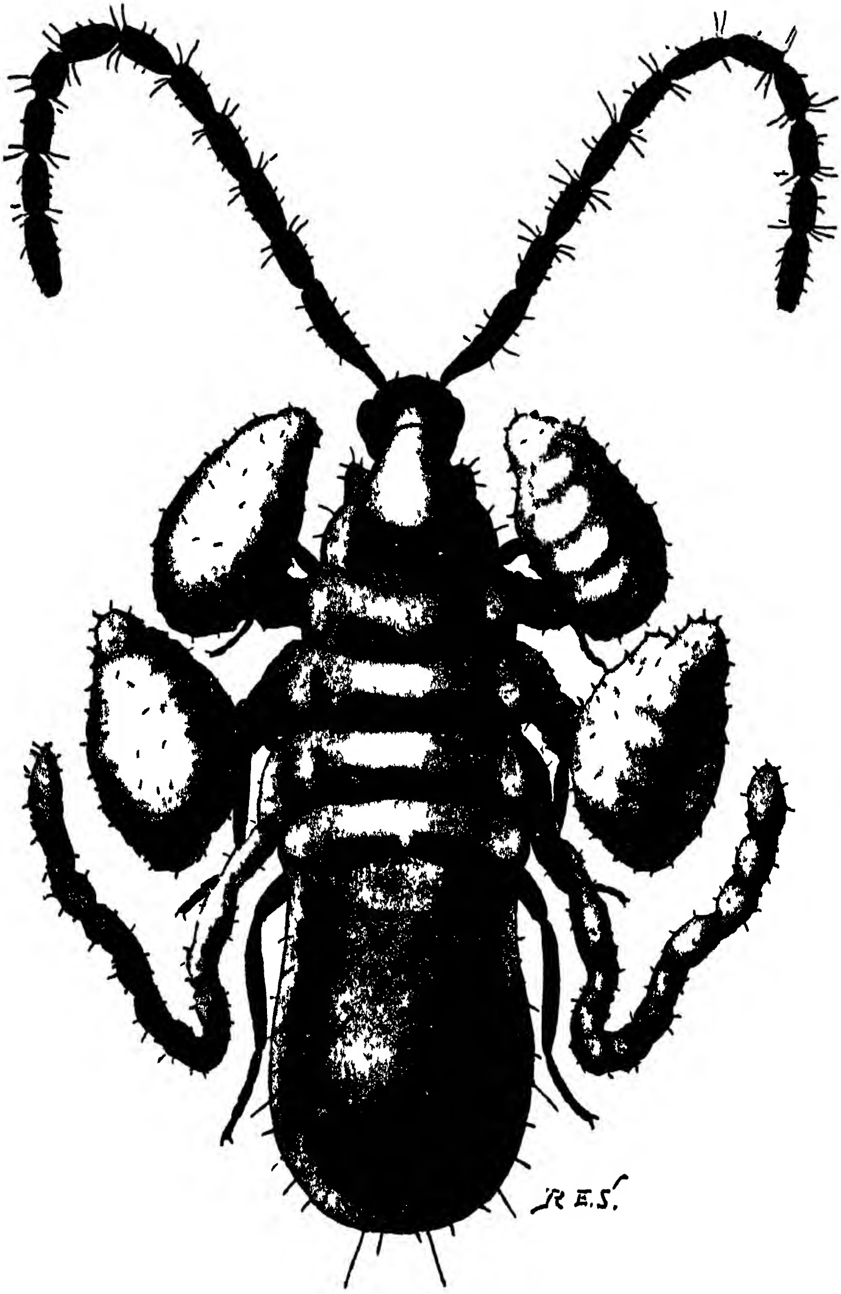


FIG. 28 *SPIRACHTHA MIRABILIS* SP. NOV.

Basal abdominal segment, the central surface of thorax and the appendages with erect hairs, which are pale yellow in color and longer on the abdomen and more sparse and black elsewhere.

Head about as long as broad, barely broader in front than behind, with a narrow median impressed submembranous area for nearly the length of front; sides posterior to eyes moderately convex; anterior border of front truncate; clypeus transverse, broadly concave at anterior border. Eyes one-third as long as sides of head, situated at front of sides. First antennal joint nearly as long as head, slender at base then gradually thickened and feebly sinuate to apex; second joint longer than broad and distinctly longer than the third; third joint twice as long as broad, joints 4-10 elongate, each a little shorter than the one preceding; terminal joint a little thicker than the others, and one and two-thirds times as long as the penultimate. Pronotum transverse, surface evenly and feebly convex, sides rounded, anterior and posterior borders broadly arcuate; separated from head by a membranous collar and with a smaller membranous pad visible at each side of the posterior border. Scutellum large, broadly triangular. Elytra together broader than long, separated for their entire length, posterior angles narrowly rounded, posterior borders nearly straight and strongly oblique. Abdomen nearly covering the remainder of body, second and third segments strongly inflated, rounded at apex; segments 3-7 with narrow transverse bands of chitin above; segments 4, 5, 6 with massive, constricted exudatorial developments, those on segments 5-6 terminating as large irregular masses, tuberculate and each tubercle bearing a stiff hair; on the fourth segment long, irregularly cylindrical, sharply bent at middle and with numerous constrictions, not as distinctly tuberculate as the other two pair Legs short and rather stout

Host.—*Nasutitermes* (*Constrictotermes*) *cavifrons* (Holmgren).

Type-locality.—Kartabo, British Guiana.

Differs from *S. eurymedusa* Schiödte in its longer head, the first antennal joint is less thickened and less arcuate, the pro-

notum lacks the broad, posterior membranous band, the elytra are separated for their entire length and their posterior borders are much more strongly oblique. The large masses at the ends of the two posterior pairs of exudatoria are characteristic. In *eurymedusa* they are slender and similar in form to the other pair and the posterior pair has one strong constriction instead of many feeble ones. The amount of membranous structure on the pronotum is variable in *mirabilis* and probably also in *eurymedusa*.

Spirachtha schiödtei sp. nov.

Female.—Length 1.50 mm.—Membranous portions white; chitin on abdomen pale brown, on head, thorax and appendages darker. Moderately shining, finely coriaceous.

Erect, stiff yellowish hairs scatered on abdomen (except on chitinous plates). Fine, black, semi-recumbent hairs on head, thorax and appendages.

Head a little broader than long; median membranous area broader than in *mirabilis;* front broadly impressed. Antennae stout, first joint nearly as long as the head, suddenly thickened near base and only slightly and very gradually enlarged toward tip, two and one-half times as long as the second joint; second joint as long as the third, less than twice as long as broad, narrow at base; joints 4-10 subequal, a little longer than broad; terminal joint one and two-thirds times as long as the penultimate. Pronotum broader than long, widest in front of middle. Elytra together broader than long, posterior corners projecting and narrowly rounded. Abdomen recurved as in *eurymedusa* and *mirabilis* but (in the majority of the specimens) extending only to anterior third of pronotum; exudatoria well developed, the anterior two pair constricted at middle into two portions; subequal in length, the apical part somewhat pear-shaped, not tuberculate but beset with bristles similar to those on second and third abdominal segments; posterior pair of exudatoria similar but with three "joints," the middle of which is small and the terminal a little larger than on the others. Legs a little more slender than in *mirabilis*.

Host.—*Nasutitermes* (*Constrictotermes*) *cavifrons* (Holmgren).

Type-locality.—Kartabo, British Guiana.

Other locality.—Kalacoon, British Guiana.

This is very distinct from the preceding species in its much smaller size, more robust antennae, broader head with more strongly impressed front and in the radically different structure of the abdominal exudatoria.

One specimen in a vial with a series of the females represents a phase of the male of this species. The structure of the head and thorax is similar to that of the female, except the median membranous band on the head is much narrower. The elytra are separated for their entire length (in the female of *schiodtei* they are connate as in *eurymedusa*) and less narrowed at the tips. The abdomen is small, entirely chitinized, compressed dorso-ventrally and margined at sides, quite a typical Staphylinid abdomen. The antennae of the specimen are broken but the basal joint is proportionately shorter than in the other specimens.

Among the series with inflated abdomens there is some variation in the length of the antennal joints and in individuals cleared in xylol I have noted differences in the internal chitinous structures in the terminal abdominal segments, which indicates that both sexes are present. So the one that I take for the male may be a phase in the imaginal development of the female. In fully developed specimens it is probable that both sexes are very similar in habitus.

It appears certain that we have two species of *Spirachtha* living in the same locality with the same host termite, another character similar to that of *Corotoca,* which Schiödte records in the same manner.

Corotoca guyanae sp. nov.

Female.—Length (in alcohol, with abdomen recurved) 2.60 mm.

Chitinous portion dark brown, except on median abdominal segments, where it is higher; lateral part of gaster yellow. Shining and every finely coriaceous.

Erect hairs fine on head, thorax and elytra, course on abdomen and shorter on appendages; one pair on vertex, numerous on ventral surface of head; scattered and sparse on thorax and elytra; abundant on gaster and arranged in three rows on each dorsal band, more scattered on the sides.

Head, excluding eyes, a little longer than broad, front shallowly impressed and, between eyes, with a v-shaped suture and a median vertical impression extending about one-third the length of head. Clypeus transverse, broadly concave at anterior border. Eyes large and convex, occupying two-thirds the sides of head. First antennal joint elongate, clavate, concave at outer border, about two-thirds as long as head; second joint half as long as the third, which is three times as long as broad, remaining joints gradually shorter, the penultimate about twice as long as broad; apical joint slender, shorter than the two preceding joints together. Pronotum a little broader than long, separated from head by a membranous collar, anterior border broadly concave; sides very broadly and obtusely angulate at anterior third, straight and moderately convergent posterior to this; surface trifoveolate, the anterior pair of foveae more elongate and less impressed than the posterior, median one; surface between the impressions low and rounded. Elytra together broader than long, sides nearly straight, posterior angles narrowly rounded, posterior border convex. Abdomen greatly inflated and projected forward; apical segment completely chitinized, penultimate segment chitinized on apical half, remaining segments (visible from above) largely membranous, each with a narrow chitinous band. Legs slender, posterior tibiae slender.

Host.—*Nasutitermes* (*Constrictotermes*) *cavifrons* (Holmgren).

Type-locality.—Kartabo, British Guiana.

Described from seven specimens taken from several nests of the host species.

C. guyanae resembles *C. melantho* Schiödte in having the front foveolate, and *C. phyllo* Schiödte in having the disc of pronotum trituberculate and the posterior tibiae linear instead of fusiform. It differs from *phyllo* in its broader pronotum, the much less pronounced tubercles and from both of the described species in the shape of the elytra, which have the outer, posterior angles broader and not acuminately produced. The maxillary palpi are markedly different in *guyanae*, the third joint instead of being thickly oval and about as long as the second, is greatly enlarged, nearly three times as long and twice as broad as the second.

Thyreoxenus gen. nov.

Female.—Small, robust species, largely membranous, abdomen strongly inflated and permanently projected over meso- and metanotum. Head very small, broader than long, not constricted behind. Labrum membranous, broad, rather narrowly concave at middle of anterior border. Mandibles small, slender, arcuate, acute at tips. Mentum broad, trapezoidal, nearly straight in front. Maxillary palpi 4-jointed, basal joint small, second joint slender, third joint thicker and oval, terminal joint small, awl-shaped. Ligula short and broad, indistinctly bilobed. Labial palpi 3-jointed. Antennae 11-jointed, first joint scapiform, remaining joints (except the apical) short; apical joint elongate, its sides parallel to near apex, then converging into a short, connate tip. Eyes small, oval, situated at sides of head. Prothorax large and convex, three times as broad as head and partly enveloping it in front; membranous except for a transverse chitinous plate on anterior half of dorsum and very narrow lateral bands that connect it with a transverse band on the sternum; dorsal plate divided at middle by a longitudinal incision, which does not extend to the anterior or posterior borders; prosternum with a median, elongate, lobe-like membranous production. Meso- and metasternum strongly chitinized, not separated by a suture, elongate, subquadrate, obtusely carinate at middle, the carina terminating anteriorly in a flat, triangular area; posterior border projecting as a broad, obtuse triangle between the posterior coxi. Elytra small, strongly divergent posteriorly, each about twice as long

as broad, with straight, subparallel sides, posterior border oblique, with corners rounded. Wings reduced to elongate, oval, pad-like vestiges. Abdomen strongly inflated, elevated and projected forward, five ventral segments visible from above; dorsal sclerites (not visible except when gaster is straightened) chitinized; ventral sclerites largely membranous but with thinly chitinous plates in front at middle; apical and penultimate sclerites chitinous, between them with a large, rounded collar-like membranous inflation.

Legs short and rather stout, femora irregularly constricted at middle. Tarsi 4-4-4 jointed; metatarsi short. Anterior and middle coxi widely separated, elongate, conical; posterior coxi less widely separated and shorter.

Male.—Similar in form to female, but smaller and more slender, with the chitin on the ventral (upper) abdominal sclerites limited to well defined, transverse bands at the anterior border of each segment except the terminal, which is chitinous throughout.

Genotype.—Thyreoxenus parviceps, sp. nov.

Though evidently a member of the tribe Corotocini *Thyreoxenus* in an aberrant genus, even in this aberrant tribe, and sharply distinct from the others in the structure of the abdomen, the unusual development of the membranous areas, in the collar-like development near the tip of the abdomen and especially in its very small head.

It is represented in the collection by three species, two small and largely white in color and one large form with dark brown pigmentation over nearly the entire body. Each appears to be a guest of a different species of Nasutitermes.

Thyreoxenus parviceps sp. nov.

Length.—(In alcohol) 2.50-2.75 mm.

Membranous portion white; chitin of head, pronotum and the femora and tibia dark brown, elsewhere pale brown tarsi

white. Appendages and abdomen with rather short, erect black hairs, their points of insertion on the abdomen marked by small, fuscous dots.

Head a little broader than long, sides behind eyes nearly straight. Eyes occupying anterior half of sides of head. Basal antennal joint as long as the four following joints together;

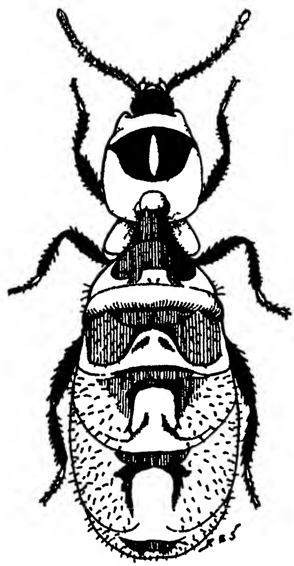


FIG. 29. *THYREOXENUS PARVICEPS* SP. NOV.

joints 2-10 subequal, only slightly larger apically, a little broader than long; terminal joint a little shorter than the two preceding joints together. Median membranous projection of mesosternum longer than broad (seen from behind) and rounded at apex; from beneath, about twice as broad as long. Posternum transversely impressed posterior to middle. Chitinous bands on upper (ventral) abdominal sclerites narrow, arranged in three sided figures.

Host.—*Nasutitermes* (*nasutitermes*) *costalis* (Holmgren).
Type-locality.—St. Joseph, Trinidad.
Other localities.—Georgetown and Kartabo, British Guiana.

Thyreoxenus pulchellus sp. nov.

(Fig. 30)

Female.—Length 2.50 mm.

Differing from *Th. parviceps* in the arrangement of the chitinous areas on the upper surface of the abdomen; the penultimate segment is evenly chitinous, the third (from the apex)

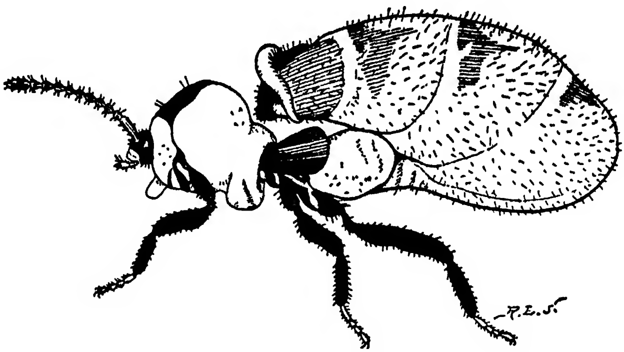


FIG. 30. *THYREOXENUS PULCHELLUS* SP. NOV.

is chitinous at the sides and in front and membranous at middle, the latter portion not bordered by a strongly chitinized margin; the fourth segment is thinly chitinous, except for a narrow, median surface rounded in front; the fifth segment is still more thinly chitinized except in front and the median, entirely membranous portion is oval in shape; the last segment (visible from above) has a transverse bar in front, similar to *parviceps*. The collar-like, membranous projection between the apical and penultimate segments is proportionately larger than in the other species.

Host.—*Nasutitermes* (*Nasutitermes*) *ephratae* (Holmgren).

Type-locality.—Kartabo, British Guiana.

Thyreoxenus major sp. nov.

Length.—(In alcohol) 3 mm.

Larger and more robust than *parviceps* and much darker in color, with the upper surface of the abdomen brown and the

second, third and fourth (from the apex) segments each with a large, quadrate median blotch considerably darker than the rest. Sides of prothorax thinly chitinized and infuscated.

Head subopaque; chitinized portions of thorax and abdomen shining. Median plate on pronotum with sparse, fine, erect hairs, much shorter than those on abdomen. Hairs on abdomen long, rather stiff and erect. Sides of prothorax uneven, impressed at middle, roundly tuberculate in front. Membraneous collar-like process on abdomen nearly absolete. Each segment of the abdomen (above) broadly impressed posteriorly to the front border; front borders elevated at middle into a rather coarse and blunt carina, which is distinctly lighter in color than the surrounding surface.

Host.—*Nasutitermes* (*Nasutitermes*) *guayanae* (Holmgren).

Type-locality.—Kartabo, British Guiana.

Described from a unique specimen.

Eburniola gen. nov.

Head small, elongate, thin in profile; only slightly narrowed behind; vertex with a strong, narrow, longitudinal impression that terminates on the front in a broad impression, which is bordered arcuately in front; anterior portion of front not produced, truncate. Clypeus membranous, strongly transverse, concave at front border. Labrum corneous, broad, anterior border scarcely concave. Submentum nearly oval, disc with a pair of conspicuous setae. Mentum small, slightly transverse; excised at middle of anterior border. Ligula very small and slender, apparently simple. Labial palpi 3-pointed, minute. Maxillary palpi 4-jointed; basal joint very small, second joint oval, a little longer than broad; third joint twice as long as broad, moderately compressed, about as broad basally as at apex, the sides little convex, rather strongly setose; terminal joint less than half as long as the third, broadly awl-shaped. Eyes situated in front of sides of head, little convex, their outer border on a plane with outline of sides of head, in outline 4-sided rather than oval, with the nearly straight sides

separated by rounded angles. Antennae situated in very small sockets at sides of anterior border of front, 11-jointed, very thick; first joint nearly as long as the three following joints together, thickly clavate and about half as long as head; second joint transverse; joints 3-10 thick, about as long as broad, subequal, quadrate in outline and not separated by constrictions; terminal joint elongate oval, one and two-thirds times as long as the penultimate.

Pronotum strongly impressed over the greater portion of the disc, anterior border elevated and narrowly rounded, posterior border sloping; sides inflexed, concealing side pieces. Elytra well developed, separated from front to rear by a narrow, triangular fissure. Chitinous portion of posternum transverse, truncate in front and behind. Mesometasternum longer than broad, median portion flat; posterior border truncate and not at all projecting between coxae. Abdomen permanently recurved, large and deeply and broadly inflated, largely membranous, nearly flat above, the marginal line weakly impressed; ventral segments strongly convex, with strong impressions between; six segments visible from above. Legs short, femora and tibae not flattened, the middle and posterior pair somewhat arcuate. Anterior coxae elongate, conical, posterior and middle shorter and conical, all moderately separated, the posterior more widely than the others. Tarsi 4-4-4 jointed, middle and posterior metatarsi elongate, but shorter than the remaining joints together.

Genotype—*Eburniola leucogaster* sp. nov.

Eburniola leucogaster sp. nov.

(Fig. 31).

Length.—(With abdomen straightened) 1.50-1.75 mm.

Pale brown, abdomen mostly ivory white, with the chitinized portions a little darker brown than the head and thorax. Gaster, especially at sides, strongly shining, remainder feebly shining and coriaceous. Head, thorax and elytra without erect hairs; pubescence sparse and exceedingly minute. Dorsal abdominal segments with an inconspicuous, erect hair on each

side; apical and penultimate segments thinly covered with recumbent, very fine yellow hairs. Basal ventral segments with abundant long and fine erect hairs, which become sparser and shorter on the apical segments and are lacking on the penultimate and terminal segments. Appendages with moderately abundant erect hairs.

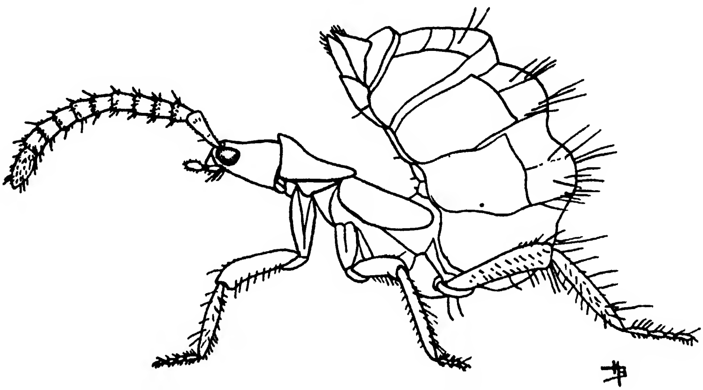


FIG. 31. *EBURNIOLA LEUCOGASTER* SP. NOV.

Head distinctly longer than broad, slightly narrowed in front. Eyes less than half as long as head. Antennae reaching to posterior end of elytra, very stout, nearly one-third as broad as head. Pronotum a little broader than long and a little broader than the head; anterior and posterior corners rounded. Elytra at base slightly broader than the pronotum, broader than long, sides divergent, arcuate at basal half, nearly straight at apical half, posterior border straight, inner angles broadly rounded, outer angles subacute. Abdomen longer than the remainder of body, more than twice as broad as the elytra; dorsal chitinous plates 1-4 very short, extending the width of the segments, each with the anterior margin broadly concave at middle; penultimate and apical segments entirely chitinized, subquadrate in shape, strongly transverse, less than half as long as the segments, extending at sides as thin lines which become obsolete before attaining the dorsum. Anterior femora of subequal width throughout; middle and posterior tibial very gradually enlarged from base to apex.

Host.—*Nasutitermes* (*Nasutitermes*) *guayanae* (Holmgren).
Type-locality.—Kartabo, British Guiana.
Other locality.—St. Joseph, Trinidad.

Described from a series of ten specimens.

Perinthus tarsatus sp. nov.

Length.—2.50 mm.

Dark brown, abdomen and appendages paler than head and thorax, moderately shining, with abundant very fine, short yellow pubescence and in addition with coarse and long black hairs arranged as follows: five on pronotal margins; two on elytral margins; one on each elytron; a series of four (interspersed with shorter and finer hairs) at the posterior border of each abdominal segment above and from four to six beneath. Antennae with a series of long hairs at the apex of each joint.

Head a little broader than long, front not margined, rather flat, vertex convex. Antennae distinctly longer than the head and pronotum together, basal joint slightly shorter than the second and third together, joints 4-11 strongly compressed, a little longer than broad; terminal joint suboval, one and one-third times as long as the penultimate. Pronotum about one-third broader than long, narrowest in front, sides convex, anterior and posterior corners broadly rounded, anterior border concave, posterior border concave at sides, slightly convex at middle. Elytra basally as broad as the pronotum, sides feebly convex, posterior angles obtuse, posterior border nearly straight. Abdomen longer than remainder of body, connate, first five segments margined. Tarsal claws long and very slender.

Host.—*Nasutitermes* (*Nasutitermes*) *surinamensis* (Holmgren).
Type-locality.—Kartabo, British Guiana.

P. tarsatus is nearest to *silvestrii,* but that species has antennal joints 7-10 slightly transverse, the terminal joints is twice as long as the penultimate and the body above is not setose.

Perinthus wasmanni sp. nov.

Length 1.60-2 mm.

Dark reddish brown, elytra darker than the rest and the abdomen and appendages paler. Moderately shining and microscopically punctate and covered with rather abundant, fine and short yellow pubescence and in addition fine, long and erect hairs arranged as follows: six on lateral margins and twelve on the disc of pronotum; two at the lateral margins and two on the disc of each elytron; a row of four at the posterior border of each abdominal segment above and a row of six to eight beneath. Antennae with shorter and rather stiff hairs. Legs with dense short hairs.

Head broader than long, rounded at sides, front flat, vertex convex. Antennae slightly shorter than the head and prothorax together; the first joint a little shorter than joints 2-3 together, joints 2-3 suboval and equal in length; joints 4-10 strongly compressed, subequal, slightly broader than long, terminal joint nearly as long as the two preceding joints together. Pronotum about one and two-fifths as broad as long, narrowest in front, sides moderately concave, anterior and posterior corners rounded, posterior border concave at sides, convex at middle. Elytra as broad basally as the pronotum, together more than twice as broad as long, sides nearly straight, anterior corners broadly rounded, posterior corners obtusely angulate.

Host.—Nasutitermes (*Nasutitermes*) *ephratae* (Holmgren).

Described from a small series.

This species in habitus closely resembles *dudleyanus* Casey from Panama but may be distinguished by the relatively short elytra. In *dudleyanus* the length of the suture is nearly two-thirds that of the pronotum; in *wasmanni* it is less than half.

Perinthus vestitus sp. nov.

Length 1.90-2 mm.

Reddish brown, elytra darkest, abdomen and legs lightest. Head, thorax and abdomen very distinctly, though shallowly

punctate and thickly covered with semi-recumbent, yellow pile much longer than that of *wasmanni* or *tarsatus* and in addition with a series of four strong black hairs on the lateral borders of pronotum, two on the outer margins of the elytra and a row on the ventral abdominal segments; abdomen also with long, fine and yellow hairs on the posterior margins of the segments.

Head barely broader than long; front flat, vertex convex. Antennae much shorter than head and pronotum together, first joint nearly as long as the second and third together, second and third joints elongate, sub-cylindrical, remaining joints compressed, all a little longer than broad, terminal joint nearly as long as the two preceding joints together. Pronotum about one-fourth broader than long, only slightly narrower in front than behind, sides feebly convex, anterior border nearly straight, posterior border feebly convex at middle. Elytra a little narrower than pronotum, together much broader than long, sides nearly straight, posterior corners angulate, posterior borders straight. Abdomen rather broadly margined.

Host.—*Nasutitermes* (*Nasutitermes*) *octopilis* (Banks).
Type-locality.—Kartabo, British Guiana.

The comparatively long and dense pubescence and the arrangement of the setae, with the more elongate and different shaped pronotum distinguish *vestitus* from the other species of *Perinthus*. The long hairs on the dorsal segments of the abdomen are unusually fine and are yellow in color, similar to the shorter hairs.

Tribe Oxypodini

Termitogaster simulans sp. nov.

(Fig. 32).

Length (with abdomen straight) 3 mm.

Head, thorax and elytra dark brown; front of head, abdomen, ventral surface and antennae reddish brown, legs and palpi yellowish brown. Rather strongly shining and finely alutaceous; outer and inner inflexed portion of elytra densely

punctate. Erect hairs on head, thorax and elytra, short and fine, several at sides of occiput, four rows of 4-5 each on pronotum and a row of four on each elytron; each dorsal sclerite of abdomen with two pairs of longer, black, erect hairs, one pair at middle of basal border and one at middle of posterior third, the apical borders with a row of long recumbent

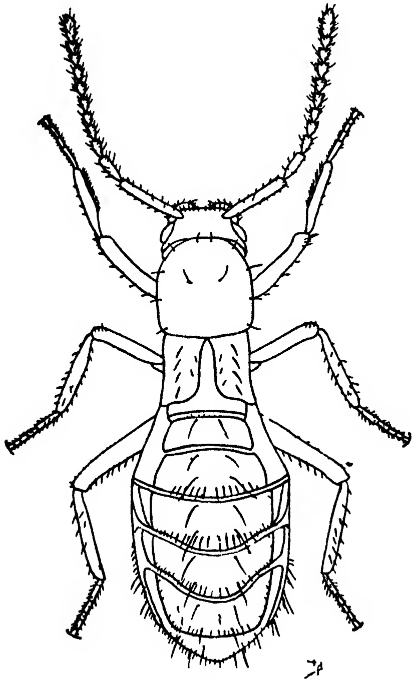


FIG 32 *TERMITOGASTER SIMULANS* SP. NOV.

yellow hairs; sides of dorsum and the sides and ventral surface with moderately dense yellow pubescence; appendages with short and rather stiff, flattened, oblique yellow hairs.

Head about as long as broad, distinctly widest at occipital border which is broadly arcuate; front concave on either side, longitudinally convex at middle to opposite antennal surface, where there is a broad, transverse elevation with an oblique anterior face and truncate borders. Labrum distinct, convex at sides, strongly excised at middle of anterior border. Eyes prominent, oval, a little less than half as long as head. First

antennal joint a little shorter than head, in cross section subquadrate; second joint nearly four times as long as broad and one and two-thirds times as long as the second; third joint more than half as long as the second, distinctly longer than broad; joints 4-10 gradually shorter, the tenth scarcely longer than broad; terminal joint elongate-oval, narrowed and rounded at tip. Pronotum a little longer than broad, with nearly straight subparallel sides, with strongly arcuate anterior border and rounded angles, posterior border, narrowly and shallowly concave at middle; surface with a longitudinal very shallow median impression in front of middle and a flattened triangular area at middle near posterior border. Elytra at base as broad as pronotum, similar to those of *simopelta* but with the posterior margin concave and the outer angles less projecting. Abdomen large, evidently not held erect, in all the specimens before me it is strongly compressed and about twice as long as broad. It may not be as strongly compressed in life, as a distinct marginal line is present, but it is so in the alcoholic as well as in the dried specimens before me); segments comparatively long, each with a transverse carina posterior to middle; membranous portions narrow, not visible in all specimens. Legs slender, middle and posterior femora strongly flattened and bent; tibiæ moderately flattened; metatarsi shorter than the remaining tarsal joints.

Host.—Nasutitermes (*Nasutitermes*) *costalis* (Holmgren).
Type-locality.—Kartabo, British Guiana.

Described from nine specimens taken with several colonies of the host termite.

In three of my specimens the sixth abdominal segment has the border evenly emarginate, as described by Casey in the male of *Termitogaster fissipennis,* the others, presumably females, have the border produced, but rounded instead of angulate.

The resemblance to a worker termite is strong even in dried and pinned specimens and must be strikingly so in the

living beetle. From the structure of the abdomen, it is evidently carried straight, or but slightly elevated.

Termitogaster simopelta sp. nov.

(Fig. 33).

Length (with abdomen straightened) 2.50 mm.

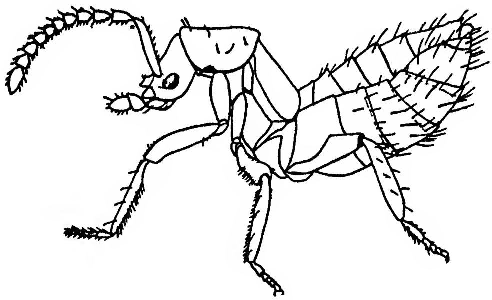


FIG 33. *TERMITOGASTER SIMOPELTA* SP. NOV.

Color pale yellowish brown, elytra a little darker than the remainder; exposed membraneous portions white. Integument alutaceous, shining, the gaster more than the rest.

Erect hairs short and rather stiff, black in color, lacking on head, ten on disc of pronotum, two on each elytron; a row of 4-6 at the middle of each dorsal abdominal sclerite (the posterior border of each sclerite with a thin row of recumbent hairs); more abundant on ventral surface of abdomen; short on appendages where there are also abundant, fine and short, erect yellowish hairs. Ventral surface of thorax with dense and very fine yellow pubescence.

Head about as long as broad, vertex transversely convex, front concave, except near anterior margin where there is a transverse ridge, thick basally and acute above (appearing dentiform from the side), anterior border obliquely concave at sides, acutely excised at middle, with a thin, sharp triangular erect tooth at either side of incision. Clypeus very short and broad, strongly concave at middle of anterior border. Labrum

transverse, longitudinally impressed at middle and convex at sides. Eyes oval, rather strongly convex, nearly half as long as head, situated in front of middle of sides. First antennal joint a little shorter than head, in cross section subquadrate, the sides somewhat flattened, and seperated from each other by an angle; second and third joints a little thicker than the others and about twice as long as broad, following joints scarcely longer than broad and decreasing in length to the penultimate which is as broad as long; apical joint oval, less than twice as long as broad and narrowed at tip. Pronotum about as long as broad, sides and anterior border nearly straight, posterior border rounded at middle, disc broadly concave in front of middle. Elytra together longer than broad at base; narrowly connected at base, the remainder broadly separated; each elytron two and one-half times as long as broad, with feebly concave outer border, straight innner border and concavely oblique posterior border with the outer angles slightly produced. Abdomen widely inflated, two and one-half times as broad as the pronotum, all segments, except the apical, margined; membranous portions narrow, in some specimens not visible between the dorsal sclerites. Legs moderately long; femora and tibiae strongly flattened; posterior femora on upper border concave at basal five-eighths, then oblique, the margin forming, in outline, a broad triangle posterior to middle; anterior tibiae with a brush of coarse, rather flat yellow hairs, arranged in two rows; each metatarsus a little shorter than the other tarsal joints together.

Host.—*Nasutitermes* (*Nasutitermes*) *costalis* (Holmgren).
Type-locality.—Kartabo, British Guiana.

Termitogaster emersoni sp. nov.

(Fig. 34).

Female.—Length (in alcohol and with abdomen straightened) 3 mm. Color brown, pronotum dark brown to black, membranous portions white. Shining. Sparse erect hairs on head, three rows of four each on pronotum, one on each elytral

disc, one at the side of each dorsal abdominal sclerite (a row of recumbent hairs on the apical margins) and scattered and more abundant on the vertical surface.

Head a little broader than long, front broadly concave, sides posterior to eyes feebly convex, occipital border broadly rounded; anterior border very slightly concave. Labrum trans-

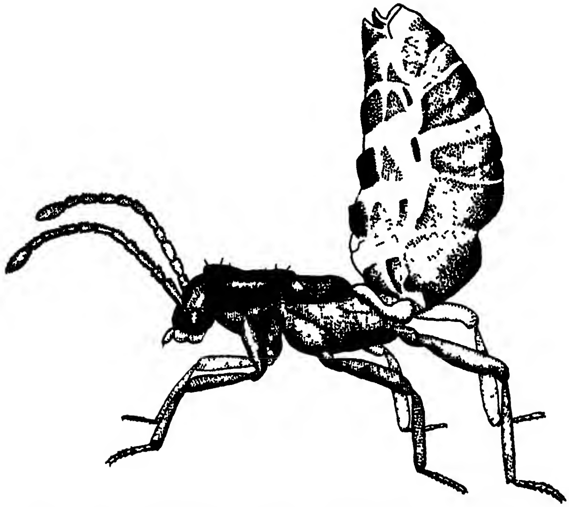


FIG. 34. *TERMITOGASTER EMERSONI* SP. NOV.

verse, broadly concave in front. Eyes oval, less than half as long as head and situated near anterior border. First antennal joint as long as head, second and third joints nearly three times as long as broad, joints 3-10 proportionately shorter, but all distinctly longer than broad, decreasing in length apically; terminal joint less than twice as long as the penultimate. Maxillary palpi with the basal joint very small, second joint broader than long, its greatest width at anterior border, which is nearly straight and rather pointed at the angles, outer surface convex, inner surface concave; third joint as long as the second, longer than broad, gradually narrowed apically; apical joint minute and spiniform, less than half as long as the third. Joints of labial palpi very small and slender. Mandibles stout, acuminate apically, thickened at middle. Pronotum wider than the head, about as broad as long and slightly broader in front than behind, sides and posterior border convex, the angles

broadly rounded, anterior border moderately projecting and rounded at the middle; surface in front of middle with a pair of broad and rather shallow impressions and behind middle with a pair of smaller and less distinct pits. Scutellum distinct, broadly triangular. Elytra shorter than the pronotum, separated at apex by a V-shaped area about half their length, together much broader than long, humeri subgibbous, sides feebly arcuate, posterior angles projecting and narrowly rounded, posterior border concave. Abdomen widely inflated, longer than the remainder of body, more than twice as broad as elytra, sides arcuate, broadly margined, the segments separated by broad bands of membrane. Legs moderately long and slender, middle and posterior metatarsi long, anterior metatarsus one and one-half times as long as the second joint.

Host.—*Nasutitermes* (*Nasutitermes*) *ephratae* (Holmgren).
Type-locality.—Kartabo, British Guiana.
Other locality.—St. Joseph, Trinidad.

Described from a series of specimens taken from several nests.

This species is near *T. brevis* but distinct in its larger size, more elongate structure, the more shallowly impressed front of head and in the strongly impressed pronotum and the separated elytra, as well as in having the membranous portions more developed than in the other species of Termitogaster.

Termitogaster brevis sp. nov.

Female.—(in alcohol and with abdomen straightened) 2.75 mm.

Chitinous parts brown, pronotum dark brown to black, membranous portions white. Shining, microscopically punctate. Erect hairs black, fine, scattered on anterior portion of head; arranged in four rows of five on the pronotum; one on each elytron at base; four on each abdominal sclerite above, shorter on ventral surface; posterior margin of each abdominal segment with a row of very fine recumbent hairs.

Head broader than long, vertex rather strongly longitudinally impressed at middle and with more shallow impressions lateral to this; anterior portion of front broadly and shallowly impressed tranversely and separated from the remainder by a carinae that extends transversely in an irregular arc across the front; anterior border broadly and strongly excised. Eyes oval, convex, occupying anterior half of sides of head. First antennal joint as long as head, somewhat flattened basally; second and third joints subequal, less than twice as long as broad, remaining joints gradually shorter to the penultimate, which is scarcely longer than broad, terminal joint shorter than the two preceding joints together. Pronotum slightly transverse, a little broader in front than behind, sides and posterior border feebly convex, anterior border nearly straight, posterior angles broadly rounded; surface with a strong pit at middle and a more shallow pair in front of this, posterior portion with a shallow transverse groove near the border. Elytra connate, together strongly transverse, broadest behind, sides nearly straight, posterior border very broadly concave, posterior angles rounded, not produced. Abdomen short and thick, more than twice as broad as elytra, with rather weak lateral margins. Legs short and rather slender. Femora and tibiae moderately flattened.

Host.—*Nasutitermes* (*Nasutitermes*) *costalis* (Holmgren).
Type-locality.—Kartabo, British Guiana.
Other locality.—St. Joseph, Trinidad.

Described from a series taken in nests of the host.

Superficially this species appears identical with the genotype, *T. insolens* Casey from Panama, but comparison with the type shows a number of differences in the structure of the head, which, in *insolens*, is comparatively longer; the median vertical impression is feeble, the anterior portion of front is not so distinct from the remainder and the anterior border is broadly arcuate, instead of excised as in *brevis*.

The maxillary palpi of *brevis* are shorter and broader than in *emersoni*, the third joint is oval, much less than twice as long as broad and distinctly shorter than the second.

Corymbogaster gen. nov.

Head small, thin in profile, subquadrate, not narrowed behind; neck broad; front shallowly, triangularly impressed, the impression bordered in front by a broadly arcuate carina, the surface anterior to which is oblique and divided by a strong, semi-circular impression at middle into two small, flat subquadrate lobes. Clypeus entirely membranous, transverse, strongly excised at middle. Labrum thinly chitinized, elongate and rounded at apex. Mentum coriaceous, small, concave behind, flat in front, anterior portion narrowed and rounded, with a minute incision at middle of border. Ligula well developed, a little longer than broad, subtriangular, rounded apically. Labial palpi 3 jointed, basal joint stout, longer than broad, nearly twice as broad as the second joint which is quadrangular in outline; apical joint one and one-half times as long as second, more than half as broad, blunt at tip. Maxillary palpi 4-jointed, basal joint small, second joint elongate, inner border straight, outer border evenly arcuate; third joint elongate oval, about three-fourths as long as the second; apical joint subulate, half as long as the third. Eyes convex, prominent, nearly circular in outline, situated at sides close to anterior border. Antennae 11—jointed; basal joint shorter than the two following together, joints 2-3 elongate, 4-10 moniliform, terminal joint elongate, with sides subparallel to near tip, then pointed. Prothorax well developed, nearly flat above, the sides inflexed, and concealing the side pieces; prosternum with an anterior chitonized portion more than twice as broad as long and truncate in front and behind, posterior portion membranous; coxae separated, elongate, conical. Meso—and metasternum not separated by a suture, together but slightly longer than broad, anterior and posterior borders concave; coxae narrowly separated by a rounded carina, that extends between the convex anterior and posterior portions; posterior coxae elongate, conical and narrowly separated. Elytra well developed, as long as the pronotum and much broader, separated by a narrow fissure. Abdomen very large and capable of great distension, in the non-distensed specimens it is but slightly longer than broad, broadest at middle, the dorsal sur-

face convex at middle, sloping at sides, separated from the side portions by a rather deep marginal line; each segment at sides produced as a very large bulbous mass which is separated at middle by a longitudinal impression; ventral segments strongly convex, separated from lateral portions by a marginal line. Legs short; femora somewhat broadened at basal half and narrowed in front; tibiae very slender at base, feebly and gradually thickened toward apex. Tarsi 5-5.5 jointed, metatarsi short; claws very slender.

This genus is widely isolated from *Termitogaster,* though probably related more nearly to it than to any other genus in the Caloderae group. The flattened head and thorax, the structures of the maxillary, and labial palpi, the antennae, and the short metatarsi are very characteristic.

Genotype—*Corymbogaster miranda* sp. nov.

Corymbogaster miranda sp. nov.

(Fig. 35).

Length.—(with abdomen straightened) 2.10-3 mm.

Dark brown to black, sides of abdomen and the tarsi brown; membranous portions white. Gaster and elytra rather strongly, the rest moderately shining; very finely coriaceous. Erect hairs long, coarse and black; a pair on lateral margin of head posterior to eye; scattered and moderately abundant on pronotum and elytra; six at the posterior border of each abdominal sclerite except the penultimate and apical where they are arranged in two irregular rows on the apical half; three or four on each lateral sclerite and two rows of seven or eight on each ventral segment; abundant on antennae and moderately abundant on legs.

Head, slightly longer than broad and narrowest in front; broadly impressed between eyes. Eyes nearly half as long as head. Antennae short, not quite reaching the tips of elytra, thickened toward apex; first joint one-third longer than eye, slender at basal half, then thickened, about as long as the second and third together; joints 2-3 oval and twice as long

as broad; joint longer than the two preceding joints together. Pronotum longer than broad, widest at anterior corners which are rounded, sides feebly concave, anterior, posterior borders arcuate, surface moderately and evenly convex. Scutellum small, transverse. Elytra together much broader than long and broadest behind, each less than twice as long as broad;

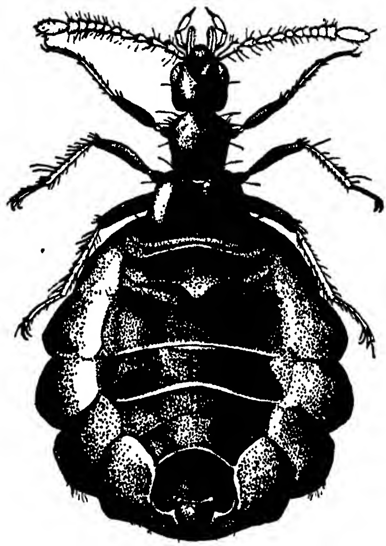


FIG. 35. *CORYMBOGASTER MIRANDA* SP. NOV.

humeri elevated and convex, sides at middle exceedingly shallowly concave, behind straight and divergent, and forming, with the oblique, nearly straight posterior border a distinct angle; inner corners broadly angulate. Abdomen nearly four times as broad as elytra and in profile three times as deep as metathorax; dorsal surface with an elevated median portion, feebly convex and separated from the flat lateral areas by a poorly defined longitudinal impression; sides separated by a strong marginal impression.

Host.—Cornitermes (*Cornitermes*) *pugnax*, Emerson.
Type-locality.—Kartabo, British Guiana.

Described from six specimens.

The description and figure based on the specimens which have the abdomen the least distended. In these the membranous portions are of limited to small portions along the margins of the dorsal surface. Other specimens have the membrane developed to such an extreme that the chitonized portions appear as small plates, the large gibbosites at the sides are greatly reduced, with the chiton showing only as a pair of very narrow, parallel plates. In one the abdomen is at least three times as long as broad and even on the dorsum the plates extend scarcely half its width.

Termitophya punctata sp. nov.

(Fig. 36).

Length.—2.75-3 mm.

Head, thorax, elytra and appendages dark brown; abdomen pale brown, each segment with a darker median blotch. Shining. Head with coarse regular separated punctures; smooth between. Pilosity stiff and erect, moderately long, very sparse except at the tip and on the ventral surface of the abdomen and on the legs, two of them near the inner border of eyes, three near the lateral borders of pronotum and two pairs on each elytral disc; one at middle of margin, stout semi-recumbent black hairs in a row of six at the posterior margins of the dorsal abdominal segments; head, thorax and elytra with very minute recumbent whitish hairs.

Head a little broader than long, front and vertex broadly convex, sides immediately in back of eyes subparallel, anterior border nearly straight. Labrum broad, strongly though very narrowly excised at middle, membraneous at middle, corneous at sides, the sides elevated into low tubercles in front. Eyes moderately convex, occupying front half of sides of head. Antennae a little longer than head and pronotum together; first joint swollen, much broader than the others and nearly as long as the second and third together; second joint shorter than third, remaining joints subequal, terminal joint shorter than the two preceding joints together. Pronotum somewhat broader than head, a little longer than broad, broadest in front

of middle and as broad in front as behind; anterior border straight, posterior border evenly convex, anterior corners rather narrowly rounded, posterior corners very broadly rounded, sides only feebly convex. Elytra as broad as pronotum, together broader than long, sides nearly straight, posterior corners rounded, border concave at middle. Abdomen con-

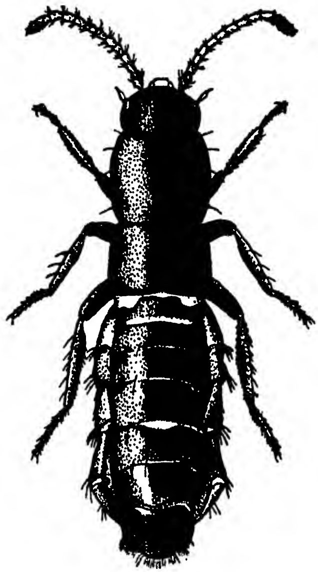


FIG. 36. *TERMITOPHYA PUNCTATA* SP. NOV.

siderably longer than the head and thorax together, broadly margined at sides for entire length; feebly convex above and rather strongly below; penultimate tergite trapzoidal, twice as broad as long and straight at the posterior border; last tergite subtriangular, with the apex narrowly rounded.

Femora strongly compressed, tibiae less compressed; posterior metatarsus one and three-fourths times as long as the remaining joints together; claws moderately long and slender.

Host.—Nasutitermes (*Nasutitermes*) *guayanae* (Holmgren).
Type-locality.—Kartabo, British Guiana.

Described from four specimens.

This, and the following two species belong to the genus *Termitophya*, though none of the specimens before me bear strong cerci on the last dorsal segment, as figured by Wasmann. (Tijdschr. Ent., vol. 45, 1902, pl. 9, fig. 1) and possibly represent the opposite sex.

T. punctata is near *T. heyeri* Wasm. but has the pronotum proportionately longer and rounded instead of angulate at the anterior corners. The punctation of the head is similar in both species.

Termitophya amica sp. nov.

Length.—(with abdomen straightened) 2.75-3 mm.

Head, thorax and elytra dark brown to black; appendages and abdomen pale brown, the latter with the median portion of dorsum dark. Shining; head with fine, though distinct, separated punctures and the intervals between with short and irregular, fine and dense striolae. Pronotum and elytra smooth; abdomen and appendages coriaceous. Erect hairs fine, black, sparse on appendages, a pair on head at inner border of eyes, three on the pronotal margins, two on each elytron. Dorsal abdominal segments 1-4 with a row of six coarser, recumbant hairs at apical margin; segment 5 with a pair of erect hairs; ventral segments with sparse, erect black hairs and, apically with elongate recumbant yellow hairs. Microscopic yellowish pubescence sparse on head and body, more distinct on legs.

Head broader than long, sides posterior to eyes slightly convex, occipital border broadly arcuate, anterior border straight, front flattened, at middle very shallowly impressed. Labrum large, entirely corneous, impressed at middle, narrowly excised at tip. Eyes moderately convex, a little longer than their distance to the posterior margin of head. First antennal joint stout, nearly as long as second and third together, third joint distinctly larger than the second, scarcely longer than broad, remaining joints a little longer than broad and becoming slightly narrower toward apex; terminal joint a little shorter than the two preceding joints together. Pronotum a little longer than broad, as broad in front as behind, with feebly

arcuate sides and posterior border, straight anterior border and broadly rounded angles; surface evenly convex. Elytra at base a little narrower than the pronotum at its widest part, together broader than long, sides straight, little divergent, posterior angles evenly rounded, the borders feebly convex and meeting at broad angle. Abdomen elongate, flat above, sides elevated as broad margins. Legs short, the femora broader than in *T. punctate* and distinctly though narrowly concave at middle of flexor border.

Host.—*Nasutitermes* (*Nasutitermes*) *guayanae* (Holmgren).
Type-locality.—Kartabo, British Guiana.

Described from five specimens.

This species is very close to *T. punctata*, differing, in addition to the broader legs, in the punctation of the head, in the arrangement of the erect hairs on the elytra and in having the pubescence more conspicuous.

Termitophya flaviventris sp. nov.

Length.—(with abdomen straightened) 3 mm.

Head, thorax and elytra rather pale brown; ventral surfaces and appendages lighter; dorsal surface of the abdomen yellowish, except for a median brown stripe. Shining, head finely and shallowly punctate; abdomen coriaceous. Erect hairs fine and shorter than in the other species; lacking on dorsal portion of head; four on sides of pronotum, two on each elytron. Coarser, black, semi-recumbent hairs arranged in rows of six unequal in size at the apical margin of abdominal segments 1-4 and one on either side of the same segments, one pair on penultinate segments and a row, mixed with long yellow hairs at the tip of apical segment; arranged in four irregular series on each ventral segment. Long and very fine yellow recumbent hairs scattered on dorsal surface of abdomen and arranged in rows at apices of ventral segments. Pubescence fine and recumbant, yellow in color, more conspicuous than in *punctata* and *amicus* and sparsely and regularly distributed on head, thorax and appendages.

Head transverse, similar to that of *amicus;* clypeus strongly and broadly convex. Labrum deeply and acutely incised at apical borders. First antennal joint much thicker than the others, a little shorter than joints 2-3 together; second joint thicker and somewhat shorter than the third, which is about twice as long as broad; remaining joints gradually decreasing in length; terminal joint one and three-quarter as long as the penultimate. Pronotum a little broader than long, straight in front, feebly convex at sides and posterior border, with the corners broadly rounded; surface moderately convex except in front of middle when it is very shallowly impressed. Elytra at base slightly narrower than pronotum; sides straight. Posterior angles broadly rounded; posterior borders obliquely convex and meeting at an obtuse angle. Abdomen elongate, the sides elevated as strong margins. Legs short; femora and tibiae broad and strongly compressed.

Host.—*Nasutitermes* (*Nasutitermes*) *costalis* (Holmgren).

Type-locality.—Kartabo, British Guiana (Aug. 1), St. Joseph, Trinidad.

Distinct from *T. amica* in its paler coloration, more distinct pubescence, the arrangement of the erect hairs and in the more slender antennae, all joints of which are more elongate in *flaviventris.* The two species are otherwise very similar.

Trachopeplus gen. nov.

Head suboval, broader than long, front with two strong lateral impressions confluent with antennal fossae, and a small median impression. Eyes rather large, oval and convex. Clypeus membranous, very short and broad, anterior border straight at middle. Labrum coriaceous, short, divided into two lobes by a strong, triangular median incision. Gula very short, with sides straight and divergent behind and not separated from submentum by a suture. Submentum large, a little broader than long, flat behind, oblique and a little narrowed in front, sides of posterior portion and the anterior border straight. Labium transverse, subquadrate. Ligula large broadly incised apically. Labial palpi 3-jointed; basal joint longer than broad and a

little thicker than the second; second joint distinctly longer than the basal; apical joint minute. Maxillary palpi 4-jointed, basal joint small, second joint twice as long as broad, very narrow at base and gradually thickened toward apex, outer surface convex, inner surface concave, the third joint a little longer than the second, elongate oval in outline and two and one-half times as long as broad, with convex outer surface and shallowly concave inner surface; apical joint exceedingly short and blunt at tip. Antennae 11-jointed, not thickened apically, first joint strongly scapiform, remaining joints elongate. Pronotum broad, strongly excised at middle, sides inflexed. Pronotum transverse, anterior border membranous; anterior half composed of a transverse chitinous plate that extends laterally as narrow bands joining to the side pieces; posterior half membranous. Meso- and metathorax together a little longer than broad, anterior border strongly concave, posterior border projecting between coxae and truncate at tip, surface flat in front, convex behind. Scutellum distinct, transverse. Elytra elongate and widely separated. Abdomen inflated, carried forward over the elytra and posterior portion of pronotum; six segments visible from above; all segments margined at sides.

Legs short and stout, femora and tibiae strongly flattened. Tarsi 5-5-5 jointed; metatarsus broad, a little shorter than the other joints together; fourth and fifth joints anchylosed; tarsal claws very slender.

Genotype.—*Trachopeplus setosus*, sp. nov.

Trachopeplus setosus sp. nov.

(Fig. 37).

Length.—(with abdomen straightened) 3 mm.

Head, antennae, pronotum, and elytra dark brown to black, abdomen and ventral surface red-brown, legs yellow-brown. Shining, very finely punctate, pronotum and elytra with small tubercles, each bearing a hair. Front with sparse, rather strong punctures, elytra densely, rather coarsely but shallowly

punctate. Hairs black, very stiff, erect and moderately long and abundant on head, thorax, elytra, and appendages; on the abdomen they are semirecumbant and irregular in length and thickness, arranged in two rows of 10-12 on segments 2-5, one row on the basal segment; ten rows on the apical segment, and abundant on ventral surface (where arranged in three irregular rows) and legs.

FIG. 37. *TRACHOPEPLUS SETOSUS* SP. NOV.

Head broader than long, sides in back of eyes convex, posterior borders rounded; border feebly arcuate; antennal foveae extending to the vertex as a pair of broad, shallow depressions; anterior portion of front flat, the border a little produced and truncate apically. Clypeus broad and narrow, entirely membranous. Labrum distinctly concave at middle of anterior border. First antennal joint about as long as the head, third joint twice as long as broad, a little longer than the second and one and one-half times as long as the third; joints 3-10 distinctly longer than broad, gradually decreasing in length; terminal joint elongate, shorter than the two preceding together, with parallel sides and rounded tip. Eyes nearly half as long as head, convex, situated near front of sides. Pronotum transverse, as broad in front as behind. Sides very feebly concave, anterior border convex at middle, narrowly concave at sides; posterior border broadly arcuate at middle, nearly straight at sides; disc in front of middle broad with a deep transverse impression two-thirds its width, the surface

anterior to this nearly flat, posterior to it, convex. Elytra at base as broad as pronotum and about as long, widely separated from front to rear; each elytron nearly twice as broad as base as at apex, with straight outer border, feebly concave inner border and oblique, slightly arcuate posterior border; exterior corners subangulate. Abdomen a little less than twice as broad as pronotum, dorsal surface nearly flat, sides elevated as prominent margins Legs rather short, femora and tibiae broadly flattened.

Host.—*Nasutitermes* (*Nasutitermes*) *acajutlae* (Holmgren).
Type-locality.—Kartabo, British Guiana.

Described from two specimens. (Mouth parts on slide.)

The shape of the head, the profoundly impressed pronotum, the structure of the maxilles and tarsi and the tuberculate nature of the pronotum, as well as the abundant and vary coarse and stiff hairs are distinctive and separate *Trachopeplus* from *Termitogaster*, with which is resembles somewhat in habitus and in the form of the antennae.

While there are five tarsal joints, the fourth and fifth are closely jointed and appear superficially as one, but in a balsam mount the suture is distinct, and furthermore marked by the arrangement of the hairs, which, with the other characters, place the genus in the Coloderae group.

Xenopelta gen. nov.

Robust; gaster moderately inflated and held elevated. Head elongate, front strongly and broadly impressed between eyes, abruptly elevated and longitudinally carinate at middle in front of antennal sockets, anterior border broadly angulate at middle and slightly projecting over base of clypeus. Clypeus membranous, strongly transverse, concave at anterior border. Labrum entirely membranous, strongly and broadly excised at middle of anterior border, with the surface of the lateral portions convex. Mandibles stout basally, slender and acute at apical half, unidentate on inner border. Mentum longer than broad, its surface flat, front border moderately elevated. Ligula very small, apparently simple. Labial palpi 3-jointed, the basal

and second joints much thicker than the terminal. Maxillary palpi 3-jointed; basal joint very small, second joint with the upper surface greatly produced into a chitinous, asymmetrical, arcuate lobe, that extends nearly to the apex of the third joint, basal portion flat; third joint thick, strongly convex above and nearly straight beneath. Antennae 11-jointed, not thickened apically; first joint scapiform. Eyes large, situated at sides of head. Prothorax elongate; disc of pronotum strongly im-impressed, sides elevated into thick rounded margins, anterior border elevated, projecting, narrowly rounded; posterior margin with flat surface and broadly rounded border. Elytra well developed, a little broader than long. Abdomen moderately inflated, more convex beneath than above; seven segments visible from above, all segments, except the terminal, broadly margined, lateral borders and the areas between the segments, both dorsally and ventrally, with narrow bands of white membrane.

Prosternum in front of coxae elevated into a ridge which is projecting and triangular at middle. Metasternum transverse, surface at middle convex; posterior border truncate between coxae. Anterior coxae large and conical, approximate. Middle and posterior coxae short,, rather broad, separated. Legs flattened, tibiae especially so, the hind tibiae with the border very thin and with an indication of a submarginal line on inner surface. Tarsi 5-5-5 jointed, the joints sharply distinct; hind metatarsus a little shorter than the remaining joints together.

Genotype.—Xenopelta cornuta, sp. nov.

Xenopelta cornuta sp. nov.

(Fig. 38)

Female.—(length with abdomen straightened) 2.75 mm.

Dark reddish brown to black, gaster lighter, projecting tip of front and the apical half of tarsi yellow brown; feebly shining, the appendages more than the rest. Head and body rather coarsely, densely punctuate; appendages similarly, but much more finely sculptured; tibae with coarse setigerous punctures.

Hairs black in color, lacking on head, a row of three on lateral borders of pronotum, two on each elytron, an oblique row of 10-12 on the posterior margins of abdominal segments 2-5 and a few near the basal border; one pair on penultimate abdominal segment; finer and rather abundant on ventral surface of abdomen; shorter on appendages.

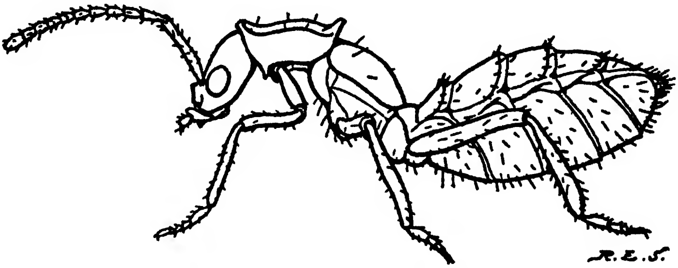


FIG. 38. *XENOPELTA CORNUTA* SP. NOV.

Head longer than broad and a little broader behind than in front, sides nearly straight, occipital corners and border broadly rounded. First antennal joint nearly as long as the head; joints 2-4 somewhat thicker than the following, the second twice as long as broad, remainder gradually decreasing in length to the penultimate which is about one and one fifth times as long as broad; terminal joint elongate oval, shorter than the two preceding joints together. Eyes less than half as long as head, situated a little in front of middle. Pronotum a little broader than head, broadest at anterior third; anterior angles rounded; depression occupying the larger part of the surface, deepest a little in front of middle with a large, shallow fovea at bottom on either side. Elytra broadest behind, with straight sides, rounded posterior corners and concave border. Abdomen one and three fourths times as broad as elytra.

Host.—Nasutitermes (*Nasutitermes*) *guayanae* (Holmgren).

Type-locality.—Kartabo, British Guiana.

Described from two females.

The basal point of the maxillary palpi is very small and visible only when the mouth-parts are dissected out.

Xenogaster fossulata sp. nov.

Female.—(length)—2.80 mm.

Head, pronotum and gaster coriaceous shining, elytra densely punctate and less shining. Hairs yellowish, fine and silky, moderately abundant on head, thorax and elytra and appendages. Dorsal segments of abdomen with a row of longer, nearly recumbant hairs at posterior border; ventral surface with fine long hairs.

Ferruginous, abdomen and legs lighter.

Head longer than broad and broader behind than in front, flat above, except for shallow elongate impressions that extend from antennal insertions a little more than half the distance to occipital border. Labrum broad, nearly straight in front. Maxillary palpi large, with the second joint distinctly longer, though more narrow than the basal; apical joint small, subulate and less than half as long as the penultimate. Eyes large, nearly flat, occupying anterior three-eights of sides of head. Antennal scapes moderately thick, extending a little less than the distance to posterior border of head, first funicular joint subcylindrical and twice as long as broad, second joint similarly shaped but shorter, joints 3-9 subquadrate in profile, slightly transverse, apical joints but little broader than the others; terminal joint oval, about as long as the two preceding joints together. Pronotum longer than broad, sides in front of middle slightly convex, behind middle straight and very feebly convergent, anterior corners subangulate, posterior border truncate; dorsum strongly impressed at middle with the sides forming rounded borders to the pit, which is deepest in front and sloping behind with the surface of the posterior, sloping portion very feebly convex toward the basal half. Scutellum large. Elytra at base a little broader than pronotum, divergent behind, widely separated, the inner border slightly concave, outer borders nearly straight, posterior border rounded at tip. Abdomen not strongly inflated, sides only slightly convex, dorsal surface flat, strongly margined and elevated at sides.

Host.—*Nasutitermes* (*Nasutitermes*) *intermedius* (Banks).
Type-locality.—Kartabo, British Guiana.

Ceratoxenus gen. nov.

Physogastric species with the abdomen carried upward and forward over the thorax. Head broader than long, not constricted behind, margined in front, with projecting, thick spinose developments. Mandibles rather thick, elongate-triangular, curved at tips. Labrum entirely membranous, very strongly transverse, concave at anterior border. Mentum subquadrate, a little broader than long, broadly concave at anterior border. Ligula membranous, simple, transverse. Maxillary palpi 4-jointed, the joints coarse, second joint thicker and about as long as the third, second and third less than twice as long as broad, their outer surfaces convex, fourth joint short, subulate. Labial palpi 2-jointed, the basal joint distinctly thicker than the second. Antennae 11-jointed, first joint scapiform, apical portion slightly enlarged. Eyes a little less than half as long as sides of head. Pronotum with sides inflated vertically; anterior, inferior angles with an elongate acute spine. Prosternum elevated and margined at anterior border; prothoracic hypomera concealed. Elytra well developed, tapering and widely separated behind. Mesosternum as long as prosternum and longer than metasternum, surface behind coxae evenly convex, triangular, projecting, coxae narrowly separated, acetabuli closed. Abdomen about as long as the thorax, strongly convex beneath, plane above, six segments visible from above, margined at sides for entire length. Legs long, rather slender. Tarsi 5-5-5-jointed. Posterior metatarsus much shorter than the remainder of tarsus.

Genotype—*Ceratoxenus tricornis* sp. nov.

Ceratoxenus tricornis sp. nov.

(Fig. 39)

Female.—(length)—2.60 mm.

Head a little broader than long, sides and posterior border moderately rounded, vertex and front broadly impressed; anterior border of front strongly margined, the margin projecting at middle as a broad triangular tooth, at sides as elongate,

bluntly pointed, laterally compressed spines. Labrum broad, concave at anterior border, from above entirely concealed by the frontal margin. Mandibles rather thick and not very acute at tips. Antennae extending to posterior end of elytra; scape thick, as long as head from above; funicular joints 1-3 elongate, subcylindrical and equal in length, remaining joints more rounded and, toward apex becoming transverse; terminal joint

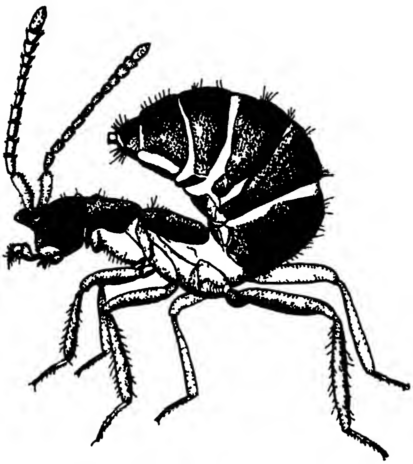


FIG 39 *CERATOXENUS TRICORNIS* SP NOV

oval, less than twice as long as broad. Eye large, moderately convex, slightly emarginate at the border approximate to antennal insertions, occupying most of the front half of sides of head. Pronotum a little broader than long, side pieces nearly perpendicular, inferior anterior angles produced as spines; dorsum with lateral and front borders roundly margined and with a transverse ridge a little in front of middle, the anterior surface evenly concave and the posterior surface impressed and plane. Elytra a little narrowed at base and about as long as pronotum, very broadly separated, (the distance between their tips equal to their length) tapering and narrowly rounded at tips. Abdomen strongly inflated and carried above thorax; dorsal surface flat, sides and venter evenly convex, dorsal segments 1-4 subequal and less than half as long as the corresponding ventral segments. Legs moderately long and slender.

Finely coriaceous and opaque throughout. Rather stiff erect brown hairs sparsely distributed on head and body and appendages. Maxillary palpi with dense yellowish white hairs.

Color ferrugineous, with the abdomen, legs and palpi lighter than the rest; membranous portions pure white.

Host.—*Nasutitermes* (*Nasutitermes*) *guayanae* (Holmgren).

Tribe—Gyrophaenae

Blapticoxenus gen. nov.

Small, rather flattened species, tapering posteriorly. Head concealed beneath pronotal margin, small, not constricted, front subtriangular, front flat. Antennal fossae with acute margins which terminate at inner border of eye and approximate at middle of anterior border of front. Genae acutely margined. Labrum elongate, nearly straight at anterior border, triangularly depressed at sides, leaving a median portion shaped somewhat similar to an hour-glass, with broad and thin lateral margins. Mandibles small, arcuate, acute at tips, the right one dentate at middle of inner margin. Maxillary palpi 4-jointed, the first three joints elongate and subequal in length, terminal joint short, subulate. Labial palpi small, 2-jointed, the joints subequal. Ligula simple, elongate, rounded in front. Eyes large and convex, with rather large facets, occupying nearly all of the exposed sides of head. Antennae 11-jointed, not geniculate, the first joint much shorter than the second and third together. Pronotum broadly convex, inflexed at sides and in front Prothoracic hypomera not visible. Anterior coxae very large and conical. Mesosternum much larger than pro-or metasternum, not carinate, slightly elevated posterior to coxae, separated from metasternum, coxal cavities closed, coxae approximated. Metasternum very short and conical. Elytra well developed, as broad as pronotum. Abdomen longer than head and pronotum together, tapering behind, first four segments strongly margined, seven segments visible from above, the sixth not impressed and the seventh not elongate. Legs short and

rather stout, tibiae not spinose; 4-4-5 jointed. First joint of posterior tarsi elongate.

Genotype—*Blapticoxenus brunneus sp. nov.*

Blapticoxenus brunneus sp. nov.

Length.—1.75-1.90 mm.

Pale brown, shining, minutely punctate. Head, thorax and elytra devoid of hairs; abdomen with exceedingly coarse, black setae at sides and on ventral surface (on ventral surface arranged in rows near posterior margins of segments); legs and antennae with finer, shorter and yellow hairs; apex of the second and third antennal joints with strong, black, hairs.

Head a little broader than long, front flat, triangular, bordered by the distinct carinae that margin the antennal fossae; sides posterior to eyes oblique, slightly concave; posterior border straight. Antennae rather slender, extending a little beyond posterior borders at elytra; basal joint thicker than the others and longer than the second. Second joint very slightly clavate and shorter than the third; joints 3-4-subequal, longer and more slender than the remaining joints which decrease in length toward the tip; terminal joint elongate-oval, rounded at apex, much shorter than the two preceding joints together. Pronotum broader than long, broadest behind middle of sides, with slightly convex sides, broadly rounded anterior corners and border and rounded posterior corners; posterior borders very feebly bisinuate. Elytra more flattened than pronotum, together more than twice as broad as long, slightly broader behind, with nearly straight sides, subangulate posterior corners, posterior border nearly straight at sides and concave at middle. Dorsal abdominal segments 1-5 broader than long, segment 6 twice as long as broad and bluntly triangular in shape.

Host.—*Nasutitermes* (*Velocitermes*) *beebei* (Emerson).
Type-locality.—Kartabo, British Guiana.

Described from three specimens (one on slide).

This genus belongs in the tribe Gyrophaenae, but the joints of the maxillary palpi are unusually elongate. The depressed sides of the front of labrum, the elongate mesosternum are very characteristic.

Family—HISTERIDAE

Thaumataerius gen. nov.

Near *Teratosoma* (Lewis).

Body subquadrate, very long and slender, flattened above. Head elongate, mandibles strong and moderately projecting. Antennae inserted a little in front of middle of inner border of eyes; first joint subclavate, broad and thick, joints 2-8 gradually increasing in size; club large, one jointed, as long as the three preceding joints together, broadly rounded at tips. Antennal fossae visible from front and sides, thinly margined by prosternum and pronotum, capable of containing the entire antennae. Prosternum flat basally, sides between coxae straight, narrowly margined, posterior border truncate; rather strongly, transversely impressed at anterior fourth. Mesosternum flat at middle, about as broad in front as behind. Pronotum with projecting anterior and posterior corners, sides diagonally impressed, with deep, elongate fossae on either side of base. Elytra elongate, flat above, anterior and posterior corners broadly rounded; sutural striae broadly impressed, extending three-fourths the length of elytra; humeri with deep, very short striae, and disc with a similar short and deep stria midway between the humeral and the sutural; anterior border bigibbous, one tubercle at base of each of the short striae. Propygidium broad and feebly convex. Pygidium with three very strong elongate costae, about half as long as the pygidium, the surface between these unevenly concave. Legs slender, moderately long; femora not arcuate; anterior tibiae with short tarsal grooves. Anterior tarsi noticeably shorter and stouter than the others.

From *Teratosoma,* known from a Brazilian species of both termitophilous and myrmecophilous habit, *Thaumataerius* differs in its very slender, elongate form, in the comparatively

simple structure of the prothorax, in the shorter and straight legs and in having the pygidium very strongly tricostate. The two genera resemble each other in the non-inflated legs and somewhat in the striation of the elytra, and though distinctly different genera, together constitute a radically aberrant group of the tribe Hetaerimorphini.

Genotype.—*Thaumataerius emersoni,* sp. nov.

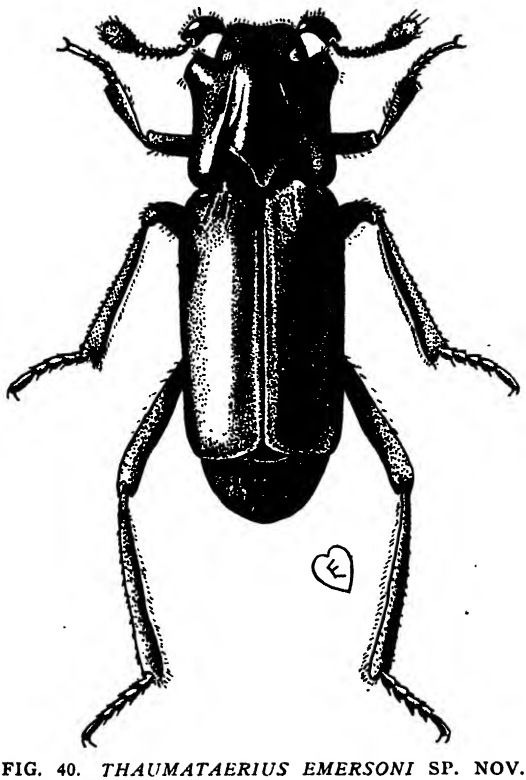


FIG. 40. *THAUMATAERIUS EMERSONI* SP. NOV.

Thaumataerius emersoni sp. nov.

(Figure 40)

Length.—2.10 mm.

Brownish red, shining; minutely punctate; body and appendages with moderately abundant, fine silky yellow hairs, which on the outer edge of the posterior and middle tibiae and shorter and denser and form a well defined brush.

Head longer than broad, not margined; vertex broad, rather strongly impressed. Eyes large, elongate, with very distinct facets. Prothorax as broad as long, slightly broadest behind, sides in front of middle feebly concave; anterior angles obliquely truncate, flattened and submargined at tip; posterior angles prolonged, with convex surface, convex outer border and narrowly rounded tip, separated from disc by strong oblique impressions which are deep basally and become shallow anteriorly; disc convex in front, shallowly concave at posterior half and separated from sides by a pair of oblique striae, one of which terminates in the lateral fossa and one of which extends to form an inner margin to the posterior angulate processes. Elytra together more than twice as long as broad, sides straight and parallel for three-fourths their length, feebly narrowed apically.

Host.—*Mirotermes* (*Mirotermes*) *nigritus* Silvestri
Locality.—Kartabo, British Guiana, July 31.

GLANDULAR STRUCTURE OF THE ABDOMINAL APPENDAGES OF A TERMITE GUEST (Spirachtha)*

By N. E. McIndoo, Ph. D.

Bureau of Entomology, Department of Agriculture, Washington, D. C.

(Figure 41, Plates XVI-XVII)

Introduction.

Some of the specimens of *Spirachtha*, collected by Mr. Alfred Emerson of the University of Pittsburgh in nests of *Nasutitermes* (*Constrictotermes*) *cavifrons* (Holmgren) in British Guiana, were given to me to determine whether or not the abdominal appendages are glandular.

Emerson informs me by correspondence that his specimens of *Spirachtha* were identified by Dr. W. M. Mann of the Bureau of Entomology as two new species—*S. schiödtei* and *mirabilis* Mann. The material sectioned by me belongs to the latter species, but Emerson made his observations on both species; however, he says: "As far as I observed, the habits of both of the *Spirachtha* were exactly the same, and both species came from the same nests."

The live insects were fixed by Emerson in hot corrosive sublimate plus a little acetic acid and then allowed to cool, and finally were preserved in 85 per cent alcohol. Parts of the abdominal appendages and the abdomen with the appendages intact were embedded in 60° parraffin. Sections were cut five microns in thickness and were stained in Ehrlich's hematoxylin and eosin. The drawings, except fig. 41, are original and were made at the base of the microscope with the aid of a camera lucida. Figure 41 was made by Emerson from a specimen, but I have added a few hairs and some shading to it.

The following references are all that I can find which relate directly to the abdominal appendages of *Spirachtha*.

---

* Tropical Research Station, Contribution Number 138.

Schiödte (1853) says: "The abdomen is furnished with three pairs of appendages, which are elongate, cylindrical, 2-jointed, membraneous, and moveable by muscles at the base. The appendages are perhaps intended for the same purpose as the tufts of hairs on the abdomen of the genus *Claviger*, which are known to be sucked by the ants." The same author (1856, p. 181), after having prepared sections from specimens preserved

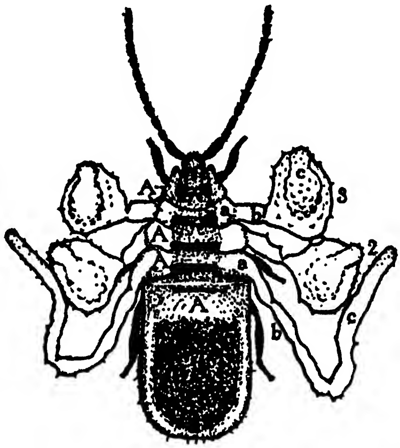


FIG. 41. *SPIRACHTHA MIRABILIS* MANN

Dorsal view showing abdominal appendages (1, 2 and 3), which consist of portions a, b and c; only the last two being glandular. Those portions marked A are the abdomen which conceals all the thorax and head, except parts of the legs, the antennae and anterior part of the head (all in solid black). Greatly enlarged. Photographed and originally drawn by Emerson, but later slightly modified by the writer.

in alcohol, was not able to decide definitely whether or not these appendages are glandular in structure. He says that there is a pair of muscles at the base of these organs, and consequently they are moveable. They are formed from prolongations of the abdominal integument, and have thick walls. Their structure appears to be homogeneous, and their contents is composed of clear granules of an irregular and globular form.

External Structure of Abdominal Appendages.

This staphylinid beetle, about the size of a common pin head, is most remarkable in that the abdomen bends forward

so that the latter lies directly over the thorax and head. Further than this, the abdomen (Fig. 41*A*) bears three pairs of appendages (*1*, *2* and *3*), the size and shape of which vary considerably in different specimens. Very few of the specimens, however, have perfectly developed appendages. Emerson says that the appendages were of various sizes or were in various stages of development when observed in the field; some possessed only small knobs on the abdomen, while in a few the appendages were well developed as shown in Fig. 41.

The first pair of appendages (Fig. 41, *1*) is unusually long and filamentous, while the second and third pairs are elongate or club shaped, but when perfectly developed their distal ends (*2* and *3*) are more or less globular in shape, as represented in Fig. 41. The appendages, when fixed in the corrosive sublimate solution, are white, soft and fleshy-like structures, and are easily sectioned. Emerson says that when the insects are alive, the appendages are held up over the abdomen; sometimes those of one side touching those of the other side. The first pair, arising from the fourth abdominal segment, is held up in the air, each resembling the letter S. The second and third pairs, arising from the fifth and sixth abdominal segments, were observed to be slightly moveable through a vertical plane at right angles to the body. Emerson observed that when the appendages were moved, all of them moved at the same instant. He thinks that both sexes develop these extraordinary appendages and that they are postimaginal structures.

Internal Structure of Abdominal Appendages.

Each appendage arises from a fleshy prolongation (Fig. 41, *a*) of the abdomen, and appears to be 2-segmented, but sections show that the articulations between portions marked **a** and **b** and between **b** and **c** are nothing more than constrictions with thinner cuticula than elsewhere. The constriction between **a** and **b** is shallow, while the one between **b** and **c** is deep. Several muscle fibers run diagonally across the portion marked **a**, but only a few other fibers unite with the integument in the constriction, and no muscles were seen in the apparent

segments b and c. Judging from this arrangement, the appendages certainly cannot be moved very much.

A microscopical examination of the integuments (not treated with KOH) of these appendages did not show any pores and only two types of hairs. The cuticula is literally covered with tiny prickles or pseudohairs and (Plate XVI, 5, Hr[1]) many comparatively large hairs (Plates XVI-XVII, 5, 14, Hr) were observed arising singly from miniature mounds, widely scattered.

Sections through the portions marked b and c (Fig. 41) reveal the most peculiar arrangement of tissues that I have ever observed. These portions (Plates XVI-XVII, 12-14) appear hollow, but are really filled with a coagulated liquid, apparently blood (Plate XVII, 14, Bl.). The walls are thick and consist of four layers; the two outermost ones being the cuticula (Plate XVII, E, D), the middle one the hypodermis (Hyp), and the innermost one the basement membrane (M) of the hypodermis. Passing through the hypodermis from the basement membrane to the outer layer of the cuticula there are many dark strands; some of these (S) are attached to the bases of the hairs (Hr), and the others (St) either to the cuticula directly or at the bases of tiny pores (P). These various structures are colored very beautifully in sections passed through alcohol containing iodine, and stained by Ehrlich's hematoxylin and eosin. The blood and basement membrane are colored pinkish by the eosin, but the later takes the deeper color; the hypodermis is stained purple by the hematoxylin; the inner layer of the cuticula (D) and the strands are stained brownish by the iodine; and the outer layer of the cuticula (E) remains unstained, being whitish or semi-transparent.

A more careful study of these various structures shows the following details. The outer and inner layers of the cuticula are practically equal in thickness. The former contains numerous tiny pores (Plate XVI, 11, P) whose outer ends are funnel-shaped, while the inner ends are straight or curved. The pores are practically all single openings, but one double pore (17) was found. These pores are peculiar in that the outer cuticula surrounding them is considerably

thicker than elsewhere, thus making semispherical projections which extend into the inner cuticula.

While there is nothing uncommon about the outer cuticula, except its pores, the inner cuticula is very peculiarly modified. The latter usually appears porous or spongy (Plate XVI, 4, 6, 8, D), but may be stratified (5, 11), or may occasionally be

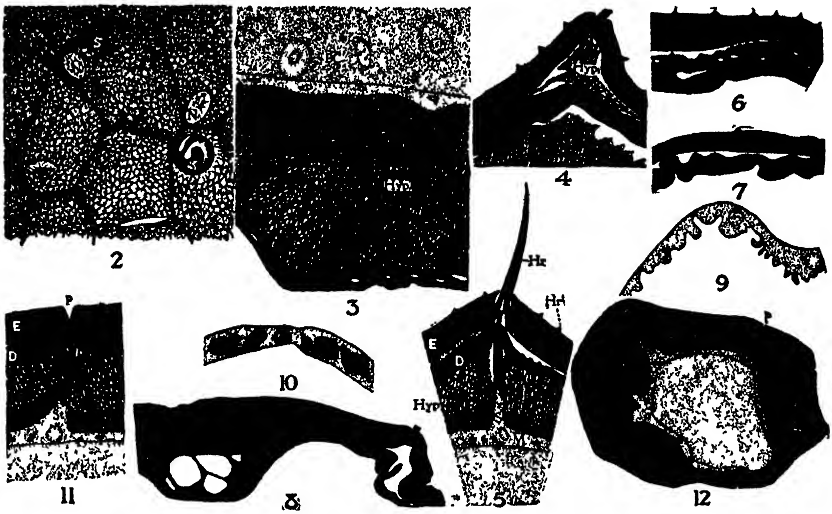


Plate XVI. *S. MIRABILIS* MANN

Internal structure of abdominal appendages.

2, end view of columnar hypodermal cells, showing nucleus (N) and stands (S and St) in cross section; 3, longitudinal view of glandular hypodermal cells (Hyp) and blood cells (BC); 4, 5 and 11, wall of appendage, showing original hypodermis (Hyp^1), hair (Hr), tiny prickles (Hr^1), outer cuticula (E), inner cuticula (D), pore (P), glandular hypodermis (Hyp), basement membrane (M), and strands (S and St) in longitudinal view; 6 to 8, various types of the dermis; 9 and 10, two types of the basement membrane; 12, cross section (semidiagrammatic) of the smaller bulb-shaped end of an appendage, showing all of the internal structures; 2 to 11, X 505, and 12, X 105.

wavy (7). It lies against the outer cuticula and is firmly anchored there by many tiny prickle-like projections (6, 8), extending into the outer layer. In order to distinguish the inner from the outer cuticula in the various drawings, a white space has been left between these two layers.

Section passing crosswise through the hypodermal cells show that these are usually five or six sided columnar cells (Plate XVI, 2), whose cut ends appear net-like and resemble

plant cells more than animal cells. Their nuclei (N) are scarcely discernible and only appear as faint elliptical areas which contain a few dark particles with a few radiating lines. It is strange that these nuclei should be so inconspicuous, because ordinarily nuclei are the most conspicuous parts of cells. Perhaps the fixation was not good for these nuclei.

Sections passing lengthwise through the hypodermal cells usually indicate that the hypodermis consists of more than one layer of cells, but upon closer examination it becomes evident that the hypodermis really consists of only one layer (Plate XVI, 3). In longitudinal sections the contents of the cells appear to consist of coagulated streaks, somewhat resembling strings of beads, which generally extend lengthwise through the cell, but sometimes diagonally across it. The longitudinal walls of the cells are conspicuous as dark lines, usually running in zigzag style, while in cross sections the walls appear as curved or straight lines. Under a high magnification each dark line appears double as shown in (2, 3).

Like the inner cuticula and hypodermis, the basement membrane is also unusually developed. So far as I am aware, the basement membrane in sections of insects almost always appears as a single line without nuclei, but in spiders (McIndoo, 1911) it appears as a double line with nuclei. This may be due to the fact that the hypodermis in spiders is always thick, never becomes atrophied, but continues to function as long as the spider lives. This explanation may possibly serve to explain why the basement membrane in these abdominal appendages is so highly developed; here both walls are always discernible (Plate XVI, 5, 9-11), and nuclei are usually seen between them. The inner wall is generally more or less smooth, but occasionally it is very rough and may bear finger-shaped or papilla-like projections (9), which extend into the blood.

For some time the dark strands, already mentioned, were a puzzle to me, but now I believe that I can satisfactorily explain them. They are very conspicuous in all the sections made, and appear in four different conditions; fragments may be seen adhering to the cuticula or bases of the hairs; small

isolated portions (Plate XVI, 2, 12, S), may be observed in either cross or longitudinal sections of the hypodermal cells; prolongations (12) of various length may be seen extending from the basement membrane into the hypodermis; and occasionally a complete strand (5, S and 11, St) may be observed. Their outer end (2, S and St) appear to be spongy and in structure are similar to the inner cuticula, but their inner ends seem to be as soft as the basement membrane. Practically every hair has a strand attached to its base, while only about one half of the pores have strands attached at their inner ends. Those strands running to the hairs look darker in sections and are much narrower than are the other ones described. The probable function of these strands is stated under "Interpretation of Results."

In life these abdominal appendages are probably completely filled with blood, because in sections the coagulated remains of the blood almost fill the entire cavity. Two types of blood cells (Plate XVI. 3, BC) were found in the blood. The smaller type, although probably not blood cells at all, is the commoner.

Interpretation of Results.

After a preliminary examination of the sections prepared, my first interpretation of these appendages was that the liquid found in them is a secretion which finds its way to the exterior through the strands and pores. This interpretation was found to be incorrect for the three following reasons: 1 The quantity of liquid contained in all six appendages is more than that of the blood contained in the remainder of the abdomen; thus, the source of any secretion must always be greater than the secretion itself. 2 This liquid contains blood cells, appears the same in structure, and has the same color as the blood found elsewhere. And 3, if the strands were efferent tubes they should be hollow in order to permit the secretion to pass freely to the exterior.

My interpretation now is that the blood passes freely through the basement membrane and inner ends of the strands into the hypodermal cells which act as secreting or gland cells.

If this is true the secretion then passes from the hypodermis into the outer ends of the strands and into the inner cuticula which serves as a reservoir to store the secretion. From this reservoir the secretion passes through the numerous tiny pores to the exterior where it probably spreads over the entire surface of the appendages and abdomen. This view is supported by the following facts. Emerson says that the termites carry these beetles about from place to place and that he often saw them lick not only the abdominal appendages but also the entire bodies of these insects. The inner ends of the hypodermal cells must be extremely active, judging from their deeper staining capacity. The basement membrane and inner ends of the strands contain coagulated particles like those in the blood, thus indicating that the blood passes freely into the hypodermis. The secretion must be different from the blood, because no remains of it can be found in the sections prepared. It may be of an oily or fatty nature and evidently totally soluble in the reagents used.

It would be interesting to know the exact sequence of formation of the various structures in the walls of these appendages. The formation is perhaps about as follows: The original hypodermis (Plate XVI, 4, 5, Hyp^1), little of which remains, first secretes the outer cuticula and hairs, then the inner cuticula; afterwards instead of its becoming atrophied as usual, it becomes greatly hypertrophied and secretes an entirely different substance which probably serves a nutritive purpose. Since the hypodermis is a thick, soft and flabby membrane it needs supports and a means of firmly anchoring it to the dermis. All of this is accomplished by the semirigid strands. Those strands attached to the hairs might originally have been trichogen cells, but now they are entirely different and certainly have a different function. In fact it seems that all the strands have originated as outgrowths from the basement membrane, because they are still attached to it and a large nucleus is usually present in this membrane where a strand departs The strands are attached to the bases of hairs and pores, because these projections serve as good places for attaching them.

The various structures, as described, are present in all parts of the appendages marked b and c (Fig. 41), but the blood chamber is not always centrally located. Sometimes, as in the smaller bulb-shaped end of an appendage, the blood chamber (Plate XVI, 12) has shifted to one side, totally eliminating the hypodermis from that side. In the portion marked a (Fig. 41) and in the remainder of the abdomen none

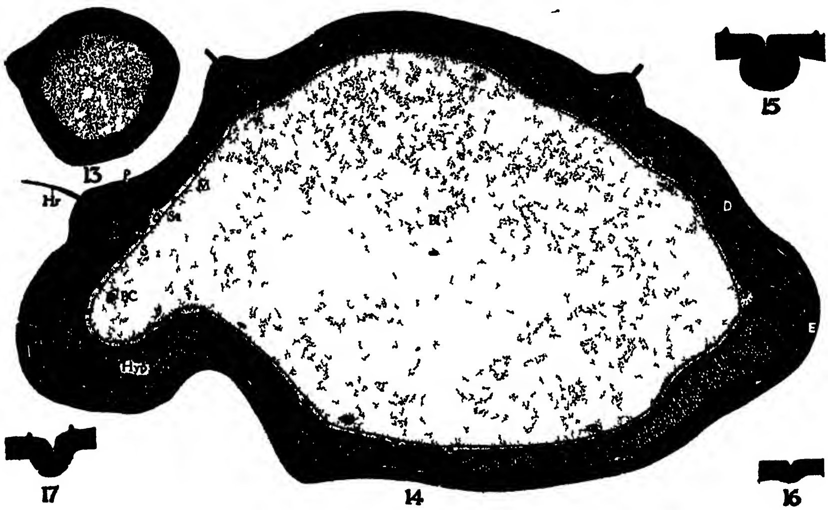


Plate XVII *S MIRABILIS* MANN
Internal structure of abdominal appendages.

13, cross section through portion b (Fig 41) of first appendage, 14, oblique section through portion c of second or third appendage, showing following internal structures pore (P), outer cuticula (E), inner cuticula (D), glandular hypodermis (Hyp), strands (S and St), basement membrane (M), blood cells (BC), and blood (Bl), both diagrammatic, and both X 105, 15 and 17, various sizes and types of pores, X 505, 15 to 17, sections similar to 14, 16, from abdomen, 15, largest pore, 16, smallest pore found

of these structures are unusually developed and only traces of some of them can be found. Starting with the proximal end of portion b and following the sections into the abdomen, it is seen that the highly developed hypodermis with its basement membrane suddenly disappears and that the inner and outer cuticula gradually become thinner so that in the portion a all that remains is: 1 a thinner outer cuticula with an occasional pore; 2 a very thin inner cuticula, slightly porous; and 3 a trace of the original hypodermis. In the abdomen the outer

cuticula is still thinner and only a trace of the inner cuticula and hypodermis can be found. Here an occasional pore (Plate XVII, 16), the smallest of all, is still present but the inner cuticula is no longer porous. In these sections there is nothing unusual about the anatomy of the abdomen. The greater part of the space is filled with the intestine, cut two or three times thus showing that it is much convoluted. At certain places the intestine seems very large and contains many particles, resembling bits of vegetable matter. Other structures, apparently eggs in their follicles are present; besides muscles, blood and the fat cells. The fat body is comparatively small and seldom lies against the cuticula.

General Discussion.

In referring to the literature on this subject, I find only one insect in which the apparent arrangement of tissues is similar to that already described for *Spirachtha;* yet in this one there is no similarity if these tissues have been correctly named. This staphylinid beetle (*Termitomimus*) was found in considerable numbers by Trägårdh (1907a) in the *Eutermes* colonies of Zululand. Trägårdh says that this genus matches *Spirachtha* with regard to the peculiar development of the abdomen and the mouth-parts. The large abdomen bears no appendages, but curves upward and forward so as to cover completely the thorax and posterior half of the head. For description he has divided the abdomen into a "pseudocaput," a "pseudothorax" and "pseudoabdomen." Sections through the "pseudothoracic" projections show four layers in the thick body wall. He calls the outer and inner layers of the cuticula epiostracum and endostracum respectively. In the position of my glandular hypodermis, he finds a cyanophilous tissue of a spongy appearance which sometimes exhibits a very distinct radial structure, sometimes is concentrically stratified and contains numerous granules which are also to be found in the trichogen cells. He thinks that this tissue is a fluid, which has either passed through the hypodermis and is a derivate from the fat body, or it is a secretion produced by the hypodermis and is coagulated by the method of fixation. It seems to

me that this tissue, which is poorly fixed, might correspond to my glandular hypodermis. In the positions of my basement membrane and the strands, running to the hairs, he finds two structures which he calls hypodermis and trichogen cells respectively. He imagines that the secretion passes through the cuticula, although he saw no pores at this place, but at other places in the cuticula near which lie fat cells he saw many extremely fine pores.

Trägårdh found two pairs of glands opening into the cuticular folds at the dorsal side of the neck of *Termitomimus.* He calls them cephalic and prothoracic glands, because the unicellular hypodermal glands of the former lie in the head and those of the latter in the prothorax. Each gland cell opens to the exterior through a tiny pore. He does not think that these glands are in any way connected with the termitophilous life of *Termitomimus.*

While it is exceptionally rare for any adult insect to bear appendages or projections similar to those already described, many larval insects bearing unusual thoracic and abdominal appendages have already been found.

Silvestri (1920) found unusual thoracic and abdominal appendages on certain dipterous and lepidopterous larvae, and also apparently eight pairs of lateral appendages on the coleopterous larva of *Troctontus,* all of which were taken from termite nests in Africa. He seems to have found glands in only the tiny club-shaped appendages of the last named insect. These consist of many very large unicellular, hypodermal glands. They lie in a thick hypodermis and open to the exterior through pores. Silvestri thinks that they secrete a special substance for the termites.

Wheeler (1918) found unusual thoracic and abdominal protuberances or appendages on three species of ant larvae belonging to the genera, *Tetraponera* and *Pachysima.* Speaking of the tubercles of *T. tessmanni,* Wheeler (p. 306) says:

"Sections and stained, cleared preparations of the whole larva show that the various tubercles contain portions of the fat body, at least in the bases of their cavities, and next to

the hypodermis a dense, granular substance, evidently a coagulated liquid produced by the underlying adiphocytes, or trophocytes. . . . Around the bases of tubercles are muscles so arranged that their contraction must increase the pressure on the fat and granular liquid and in all probability cause the later to exude through the hypodermis and delicate chitinous cuticle onto the surface. The whole arrangement of the tubercles, in fact, constitutes a system of exudate organs, or exudatoria, as I shall call them, adapted to secrete substances that can be licked up by the ants when they are feeding and caring for the larvae."

Wheeler also studied sections through the appendages of *P. latifrons* and found a similar arrangement of tissues, but in the fat cells in these sections he imagined that he saw urate crystals, which caused him to believe that these cells function as a storage kidney till the malpighian vessels are sufficiently developed to excrete. To me Wheeler has not shown any evidence that these appendages are really exudatory, but it is very probable that they are. He saw no pores in the cuticula and does not say how his coagulated liquid differs from the blood, but in support of his view he claims that we must interpret the exudatoria as very primitive glands, which in all probability have arisen as new formations and not as homologues of the embryonic legs. He (p. 313) says:

"They are, as we have seen, small diverticula like the embryonic legs, consisting of hypodermis and its overlying cuticula and containing a portion of the fat-body separated from the hypodermis by a granular liquid. Now the fat-body of the insects may be regarded as a diffuse ductless gland, the cells (trophocytes) of which take certain substances from the blood in which they lie, store them in the cytoplasm as fat-globules or proteid granules and later return them to the blood in a more finely divided, if not chemically modified form. The exudate which accumulates in the distal ends of the exudatoria is therefore merely blood charged with nutrient substances from the fat-cells, and either filters gradually through the hypodermis and overlying cuticle or is forced through them by

muscular pressure. At first sight it would seem that the cuticle must be impervious to such a liquid, but a consideration of the more recent work on the minute structure of chitin * * * shows that there is nothing to prevent the passage of a thin fatty liquid, even if it were not under pressure and even if the cuticle were much thicker than it is in the ant larva. The cuticle is a colloid, either of a reticular structure, as Kapzow believes, or formed of horizontal layers of very fine fibrillæ crossing one another at an angle of 60° as most investigators, including Biedermann and Casper, maintain. Between the fibrillæ are regularly distributed and extremely fine openings or 'pore canals,' through which a liquid might readily pass as if the cuticle were a filter."

In further support of his view, Wheeler cites the work done on certain meloid, cantharid, lampyrid, coccinellid and chrysomelid beetles in which a liquid, usually regarded as blood plasma charged with cantharidin, is discharged from the articulations of their legs. Wheeler has overlooked my work (1916) in which I found gland pores in the femoro-tibial articulations of meloid and coccinellid beetles, and in *Epilachna borealis* I described two types of gland cells which discharge the liquid through these pores. It is also possible that the other named insects have glands which discharge secretions from their legs.

Wasmann (1903), Trägårdh (1907 *a* and *b*) and Holmgren (1909) have published much concerning the exudate organs of myrmecophiles and termitophiles, but considerable of the work done on the finer anatomy is not clear to me, although Wheeler uses their results to support his view.

Wheeler (1910, p. 399) states that students of myrmecophily observed that true guests of ants generally bear tufts of hairs or trichomes which are assiduously licked by the ants, and Wasmann (1903), who has written much about these structures, shows that the trichomes are borne by the integument at points or depressions where clusters of unicellular glands open, and that they function by rapidly diffusing some

aromatic secretion. Wasmann thinks that the secretion is not liquid, but perhaps a fatty ether, thus being volatile or etherial. The ants are so fond of it that he thinks it must affect them very much as a good cigar affects a smoker. Wheeler adds: "Perhaps it would be nearer the truth to say that its fascination is more like that of catnip or oil of bergamot on the various members of the cat family."

BIBLIOGRAPHY

HOLMGREN, N.

1909. Termitenstudien 1. Anatomische Untersuchungen. K. Svenska Vetensk. Handl., Bd. 44, p. 1-215, 3 pl., 76 text figs.

McINDOO, N. E.

1911. The lyriform organs and tactile hairs of araneads. Proc. Phila. Acad. Nat. Sci., vol. 63, pp. 375-418, 4 pls.

1916. Reflex "Bleeding" of the coccinellid beetle, *Ephilachna borealis*. Ann. Ent. Soc. Amer., vol. 9, No. 2, pp. 201-221.

SCHIÖDTE, M.

1853. On some Staphylinidae, found in the nests of Termites. Proc. Zool. Soc. London, Part 21, pp. 101-103.

1856. Observations sur des staphylins vivipares qui in habitent chez les termites. Ann. Sci. Nat., Zool., quart sér., t. 5, pp. 169-183.

SILVESTRI, F.

1920. Contribuzione alla conoscenza dei Termitidi e Termitofili dell' Africa occidentale; II—Termitofili, parte seconda. Portici Bollettino lab. di Zool. gen. e Agraria, vol. 14, pp. 265-319, 32 figs.

TRAGÅRDH, IVAR.

1907*a*. Description of *Termitomimus*, a new genus of termitophilous physogastric Aleocharini, with notes on its anatomy. Zool. Studier tilläg. T. Tullberg, Uppsala, pp. 172-190, 1 pl., 10 text figs.

1907b. Notes on a termitophilous teneid larva. Ark. f. Zool., Bd. 3, pp. 1-7, 1 pl.

WASMANN, E.

1903. Zur naheren Kenntnis des echten Gastverhältnisses (Symphilie) bei den Ameisen und Termitengästen. Biol. Centralbl., Bd. 23, pp. 63, 195, 232, 261, and 298.

WHEELER, W. M.

1910. Ants, their structure, development and behavior. New York.

1918. A study of some ant larvæ, with a consideration of the origin and meaning of the social habit among insects. Proc. Amer. Phil. Soc., vol. 57, pp. 293-343, 12 figs.

TERMITOPHILOUS APTERYGOTA FROM BRITISH GUIANA*

By JUSTUS W. FOLSOM.
University of Illinois.

(Plates XVIII-XXIII).

The material upon which this report is based was collected at the Tropical Research Station of the New York Zoological Society, Kartabo, British Guiana, in 1919 and 1920 by Mr. Alfred Emerson.

The following six species are described, all of which are new, and one of which represents a new genus of Collembola.

THYSANURA: *Atelura guiana, A. lepismoidea, A. crispula, A. cucullata, Nicoletia emersoni.* COLLEMBOLA: *Borecus pinnatus.*

Types of these have been deposited with the New York Zoological Society.

All these forms except the *Nicoletia* are termitophilous. The genus *Atelura,* in particular, is strictly myrmecophilous or termitophilous, and it is appropriate here to bring together the little that has been published on the habits of this genus. Additional observations made by Mr. Emerson, appear beyond.

HABITS OF ATELURA

The statement of Escherich ('04) that all the species of *Atelura* are either myrmecophilous or termitophilous is probably still true. Of twenty-four species that I have found recorded up to the present eighteen are myrmecophilous or termitophilous, as are doubtless also the remaining six (from Africa and Australia), descriptions of which I have not seen.

According to the observations of Janet ('96*a*, '96*b*) on *Atelura formicaria* Heyd. in a nest of *Lasius umbratus* Nyl.,

* Tropical Research Station, Contribution Number 139.

the *Atelura* can get along without the ants provided it has available an appropriate nourishment; but is attracted to the nests of ants by the nutritive fluid that the ants disgorge and feed to each other. As a pair of ants stand mouth to mouth, absorbed in the process of feeding, the *Atelura* rushes in, grabs the drop of food and hurries away. This performance is repeated with other pairs of ants until the hunger of the *Atelura* is satisfied. The guests are tolerated by their hosts for the good reason that by their agility they are usually able to elude the ants, but these interlopers are constantly being chased by their victims, and are sometimes caught and killed.

In regard to the Brazilian species *Atelura termitobia* Silv., Silvestri ('01*a*) gives the following observations.

"In the royal chamber of *Anoplotermes tenebrosus* I found with the king and queen . . . three examples of *Grassiella* [*Atelura*], which were running about unmolested among the workers. I placed the royal pair, some workers and the three individuals of *Grassiella* together in a glass tube and observed that the last-named lived in perfect harmony with the termites, without at any time being pursued by them. Once I saw a *Grassiella* on the back of a queen, while the head of a worker, which had just cleaned the latter, was quite near the head of the *Grassiella*. Perhaps these thysanurans also steal food from the termites, as others do from ants."

Silvestri ('01*a*) observed the minute Brazilian species *Atelura synoeketa* Silv. in the nests of *Eutermes microsoma* Silv., and says concerning them: "In the galleries of *Eutermes* I saw three individuals of *Grassiella* [*Atelura*] rambling around in the midst of the workers, soldiers and larvae, which I captured and placed alive in a glass tube, together with their hosts. They walked about everywhere among the termites, sometimes encountering them, head to head without, however, either species making the slightest impression upon the other. I saw also a *Grassiella* enter a gallery in which there were *Eutermes* and emerge from the other side unharmed. Never did I see a *Eutermes* pursue a *Grassiella*, or vice versa."

Thus the species of *Atelura* get food and shelter in the nests of ants and termites, but the benefit is one-sided, for the hosts gain nothing from the association with their guests.

The species of *Atelura* are not usually limited to a single species of host, but most of them occur with a number of different species of ants and termites.

In distribution the genus is widespread, occurring in all the faunal realms. The species are small, as a rule, attaining at most a length of six or seven millimeters.

Mr. Emerson says, in regard to the species of *Atelura* in the nests of termites: "In all cases they seemed to be ignored by the termites. They moved swiftly about among the termites, resting very little. In no case did I observe any hostile actions toward them on the part of the termites. I observed *Atelura lepismoidea* n. sp. several times running about, closely following worker termites (*Nasutitermes* (*N.*) *acajutlae* Holmgren) but did not happen to see them obtain regurgitated food or abdominal secretions from the termites, although it is very possible that at times they obtain food in this way. They seem to be pantermitophilous, as shown by the list of the host species in whose nests they were found."

Atelura guiana sp. nov.

(Plate XVIII, figs. 1 to 11).

General color golden yellow, due to the scales; body color yellowish white. Appendages white except in large specimens, in which the antennae, bases of the legs, and of the pseudocercus ("median cercus") may be brownish yellow. Small individuals are yellowish white throughout. Form subelliptical (fig. 1), broadest across the mesothorax, with width to length as 1:2.5. Thorax five-eighths as long as the abdomen. Abdomen smoothly confluent with the thorax in outline. Body strongly arched. Thoracic terga with rounded lateral borders, projecting far down over the bases of the legs. Antennae (fig. 2) short, about nine-tenths as long as the thorax, or less than one-third the total length, with usually 12 segments, and occa-

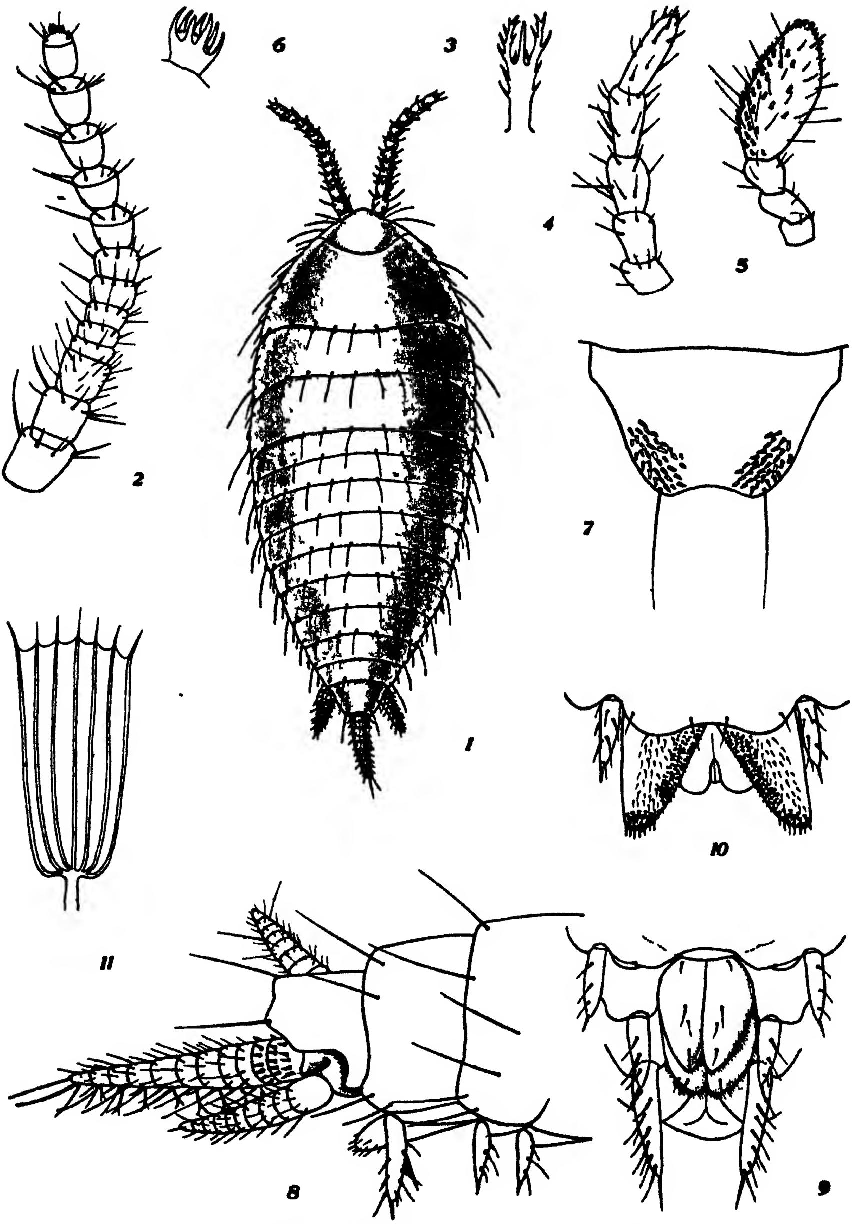


Plate XVIII. *ATELURA GUIANA* SP. NOV.

1, dorsal aspect, X 25; 2, antenna, X 66; 3, terminal sense organ of antenna, female, X 790; 4, maxillary palpus, X 86; 5, labial palpus, male, X 96; 6, sense organ from labial palpus, X 790; 7, tenth urotergite of male, dorsal aspect; the pegs are ventral in position, X 86; 8, extremity of abdomen of male, to show cerci and styli; the lower cercus in the figure is displaced, X 68; 9, ovipositor and styli, ventral aspect, X 85; 10, parameres and penis, ventral aspect, X 85; 11, typical scale from dorsum, X 505.

sionally 11 or 13; distally moniliform; last five segments each with a distal subsegment; apical segment oblong-elliptical, with length to width as 9:5 or 5:3; the three or four segments immediately preceding the apical segment subovate to subglobose; apical segment with a terminal branched sensory organ (fig. 3); second segment in male without a secondary sexual process, but with a ventral circular radiate sense organ. Maxillary palpi (fig. 4) with segments in relative lengths as 8:15:16:18:25; last segment elliptico-cylindrical. Labial palpi (fig. 5) with segments as 6:12:10:40; last segment elliptical, twice as long as broad, with sensory pegs and an apical cluster of six branching sensory papillae of the type shown in fig. 6. Tenth abdominal tergite (fig. 7) with a shallow emargination in both sexes; distal lobes each with about 35 ventral pegs in the male only. Cerci (fig.8) short; lateral cerci with about 10 segments (9-12); pseudocercus ("median cercus") one and one-half times as long as the lateral cerci, with about ten segments (10-12), and with short dorsal pegs on the proximal two segments in the male. Styli (figs. 8, 9) three pairs, on the 7th to 9th abdominal segments, respectively. Dorsal valves of ovipositor (fig. 9) longer than the ventral; ventral valves semi-ovate in ventral aspect, unsegmented. Parameres of male (fig. 10) in ventral aspect subtriangular, blunt, divergent, armed apically with short spines, and mesally with many short hooks. Body segments with dorsal rows of long outstanding hairs, mostly along the posterior border of each segment. Dorsum of head with several short hairs, apically bifurcate. Dorsal scales dense, varying in form and size, but typically as in fig. 11. Maximum length, 3.7 mm.

This species is near the Brazilian *Atelura* (*Grassiella*) *synoeketa* Silvestri ('01*a*, '01*b*) in which, however, the body is anteriorly oval, the antennae ten-segmented and one-third as long as the body, and the latter only 1.6 mm. in length.

Twenty-eight specimens, Kartabo, Bartica District, British Guiana, June 30, July 20, 27, 28, August 11, 20, 21, October 11, 15, November 4; Barakara, Bartica District, July 15. (Field Nos. 91, 108, 151, 208, 236A, 242, 248, 274, 403, 426, 476.)

Atelura guiana occurred in the nests of the following species of termites: *Nasutitermes* (*N.*) *guyanae* (Holmgren), *ephratae* (Holmgren), *octopilis* Banks, *surinamensis* (Holmgren); *Nasutitermes* (*Angularitermes*) *nasutissimus* n. subg. n. sp.; *Anoplotermes* (*A.*) sp. (No. 151); *Mirotermes* (*Cavitermes*) *tuberosus* n. subg. n. sp. All these species build conspicuous, well formed nests above the ground with the exception of *N. octopilis* and *N. nasutissimus*, which have rather loosely constructed nests.

Atelura lepismoidea sp. nov.

(Plate XIX, figs. 12 to 20).

Pale, yellow; appendages white. Body (fig. 12) two-fifths as broad as long, somewhat lepismiform, broadest across the metathorax, not strongly arched. Abdomen confluent with thorax, about 1.4 times as long as thorax, tapering in dorsal aspect, with lateral outlines straight or slightly concave. Thoracic terga rounded laterally and covering the bases of the legs. Head rounded in front. Antennae (fig. 13) as long as the head plus the thorax, with 15, occasionally 16, segments, of which all but the first 6 are subsegmented, segments 7 and 8 each having two subsegments, and segments 9-15 having three; first 6 segments in relative lengths about as 19:17:8:4:5:10; distal segments elongate, elliptical; last segment more than twice as long as broad, with a terminal sensory organ of the type shown in fig. 3; second segment in male without a secondary sexual process. Maxillary palpus (fig. 14) with segments as 13:17:19:22:32; last segment narrowly subelliptical, three times as long as broad, with a single apical branching sensory papilla. Labial palpus (fig. 15) with segments as 9:10:21:46; last segment elliptical, twice as long as broad, with an apical cluster of six sensory papillae of the type shown in fig. 6. Tenth abdominal tergite with a median rounded emargination, deep in the male (fig. 16) and shallow in the female (fig. 17); posterior lobes each with about 20 (17-21), ventral cones or pegs (fig. 16) in the male only. Cerci short; pseudocercus ("median cercus") with ten segments, the proximal two segments bearing a few dorsal pegs in the male (fig. 16), usually four pairs, becoming successively longer;

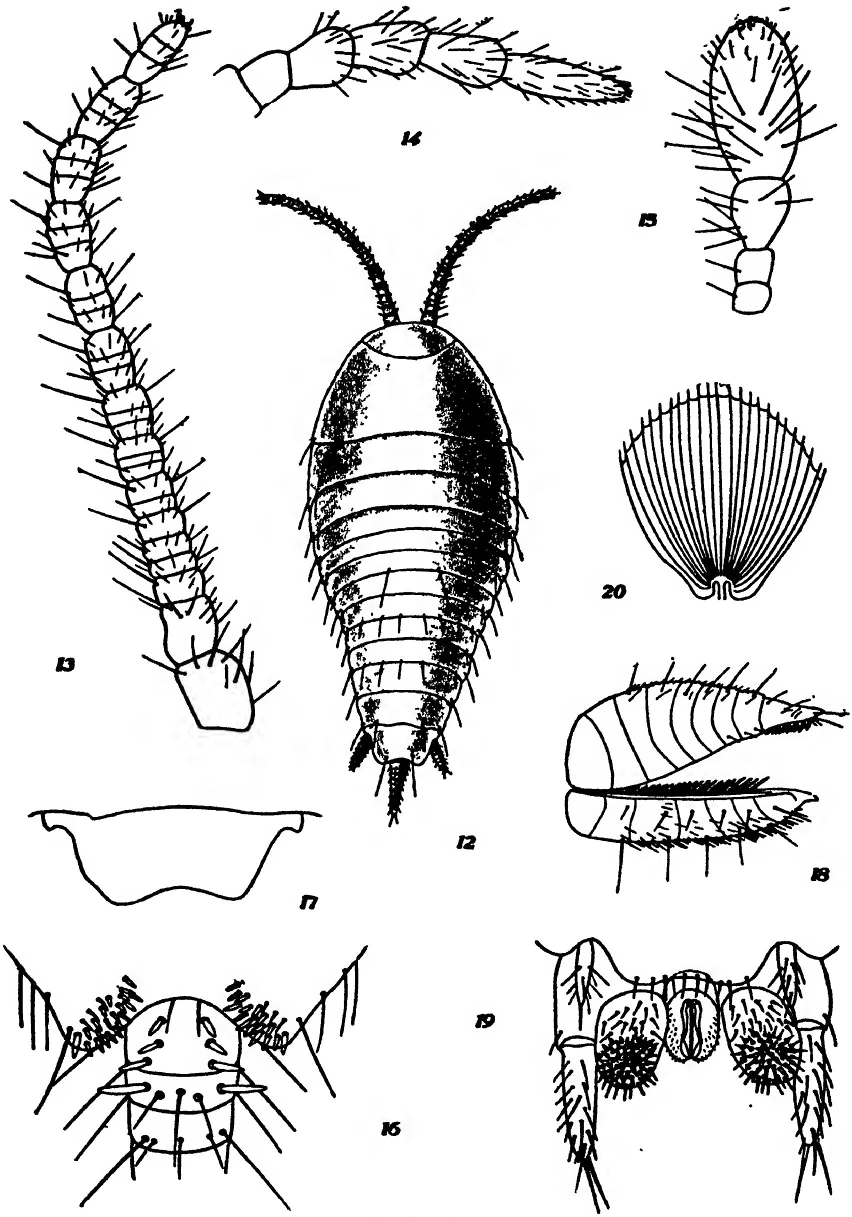


Plate XIX.

ATELURA LEPISMOIDEA SP. NOV.

12, dorsal aspect, X 25; 13, antenna, X 86; 14, maxillary palpus, X 100; 15, labial palpus, X 100; 16, dorsal aspect of extremity of tenth urotergite and base of pseudocercus of male; the pegs of the former are ventral in position, X 175; 17, tenth urotergite of female, X 86; 18, left aspect of ovipositor, X 53; 19, parameres and penis, ventral aspect, X 86; 20, typical scale from dorsum, X 505.

lateral cerci five-sixths as long as the pseudocercus, with 8-10 segments. Styli four pairs, on the 6th to 9th abdominal segments respectively. Ovipositor extending as far as, or slightly beyond the lateral cerci, with both pairs of valves segmented (fig. 18), the ventral valves smaller and slightly shorter than the dorsal. Parameres of male stout, subcylindrical (fig. 19), apically armed with many stiff spines. The long stiff dorsal hairs of the body are limited to the posterior borders of the segments; there are possibly more of these than are shown in fig. 12. Dorsal scales typically as in fig. 20, though varying in form and size. Length, 3.2 mm.

The usual number of antennal segments is 15 in both sexes, but one female had 16, and small specimens (1.7 mm. in length) had only 12, 13 or 14.

Forty-one specimens, Kartabo, Bartica District, British Guiana, July 13, 20, August 7, 18, 21, September 21. (Field Nos. 100, 197, 225, 242, 248, 339.)

Atelura lepismoidea had as hosts these five species of termites: *Nasutitermes* (*N.*) *surinamensis* (Holmgren), *costalis* (Holmgren), *acajutlae* (Holmgren), *ephratae* (Holmgren); *Armitermes* (*N.*) *teevani* n. sp. These build conspicuous, well formed nests above the ground, with the exception of *A. teevani*, the nest of which is usually on the ground.

Atelura crispula sp. nov.

(Plate XX, figs. 21 to 30).

Pale yellow; appendages white. Broadly elliptical (fig. 21); length to breadth as 1.8:1; body strongly arched, reminding one of a "sow-bug"; abdomen smoothly confluent with the thorax in outline, twice as long as the latter. Lateral borders of thoracic terga rounded, extending down over the legs. Antennae short, about as long as the thorax, or about one-third the entire length, with 14 or 15 segments, of which the last 6 or 8 have each two subsegments (fig. 22); last segment elliptical, twice as long as broad, with a terminal branched sensory organ (fig. 23). Maxillary palpi (fig. 24) with segments in relative lengths as 8:12:16:17:20; last segment elongate-conical.

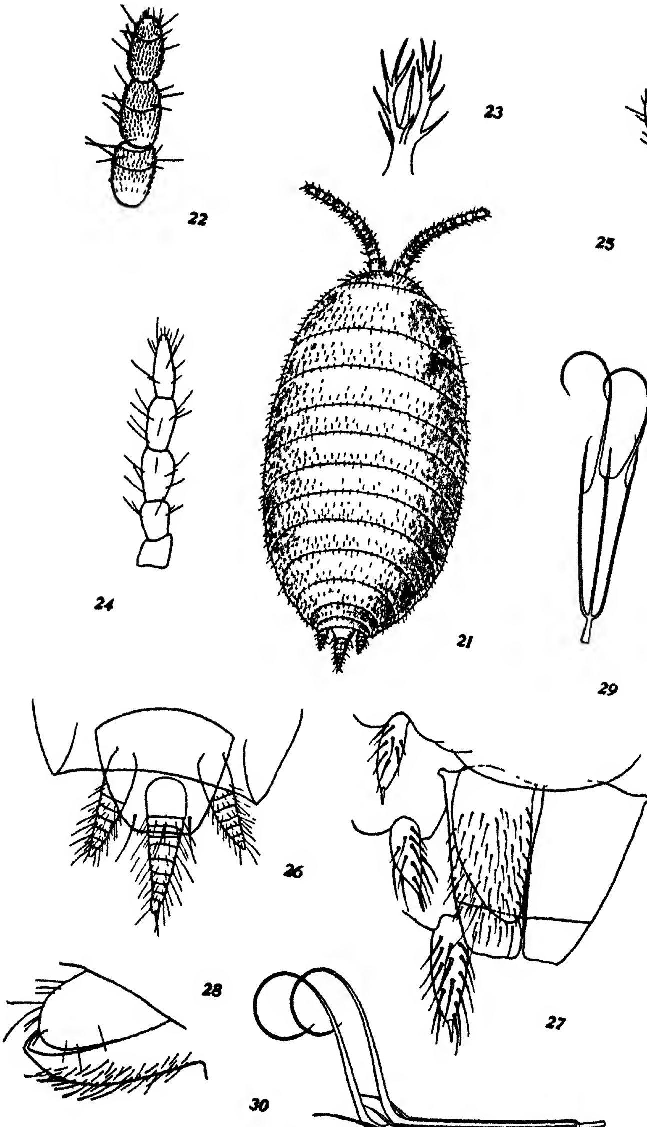


Plate XX.

ATELURA CRISPULA SP. NOV.

21, dorsal aspect, X 25; 22, last three segments of antenna, X 110; 23, terminal sensory organ of antenna, X 790; 24, maxillary palpus, X 86; 25, labial palpus, X 86; 26, tenth urotergite, cerci and pseudocercus of female, X 53; 27, ovipositor and styli of right side, ventral aspect, X 85; 28, right aspect of ovipositor, X 86; 29, dorsal aspect of scale from dorsum, X 505; 30, lateral aspect of scale from dorsum, X 959.

Labial palpi (fig. 25) with segments as 5:7:14:26; last segment elliptical, twice as long as broad, with six branching sensory papillae near the apex. Tenth abdominal tergite subtrapezoidal (fig. 26), with posterior margin entire (feebly emarginate in one specimen) and with postero-lateral borders rounded. Cerci short and stout (fig. 26); pseudocercus ("median cercus") one-fifth longer than the lateral cerci, 10- or 11-segmented; lateral cerci 7- or 8-segmented. Posterior abdominal segments short, bringing the styli close together. Styli three pairs, short and stout (fig. 27), on the 7th to 9th abdominal segments, respectively. Ovipositor short and stout (fig. 28), the ventral valves exceeding the dorsal; dorsal valves short and stout, rounded apically; ventral valves in ventral aspect suboblong, apically truncate, with a subapical transverse suture (fig. 27). Most of the hairs of the body are dense, short and stiff; long suberect hairs occurring on the head. Most of the scales, which clothe the dorsum densely, are of the peculiar and characteristic form shown in figs. 29 and 30, each scale having a pair of long curling branches. Length 2.3 mm.

Six specimens, all females, Kartabo, Bartica District, British Guiana, August 4, 1920 (No. 182).

Atelura crispula had as host *Armitermes* (*A.*) *percutiens* n. sp., which builds a fairly well constructed dirt nest on the ground or very close to the ground.

Atelura cucullata sp. nov.

(Plate XXI, figs. 31 to 39).

Golden yellow; appendages white, with pseudocercus brownish basally. Form elliptical (fig. 31), twice as long as broad, thorax to abdomen in length as 5:9. Abdomen smoothly confluent with thorax in dorsal aspect. Body strongly arched, as in a "sow-bug". Thoracic terga projecting down over the bases of the legs.

Antennae (fig. 32) short and stout, one-tenth the length of the body, 13-segmented, without subsegments; last segment ovate, the three preceding segments cup-shaped, about as broad as long. Maxillary palpi (fig. 33) with segments as 1:3:3:4:5;

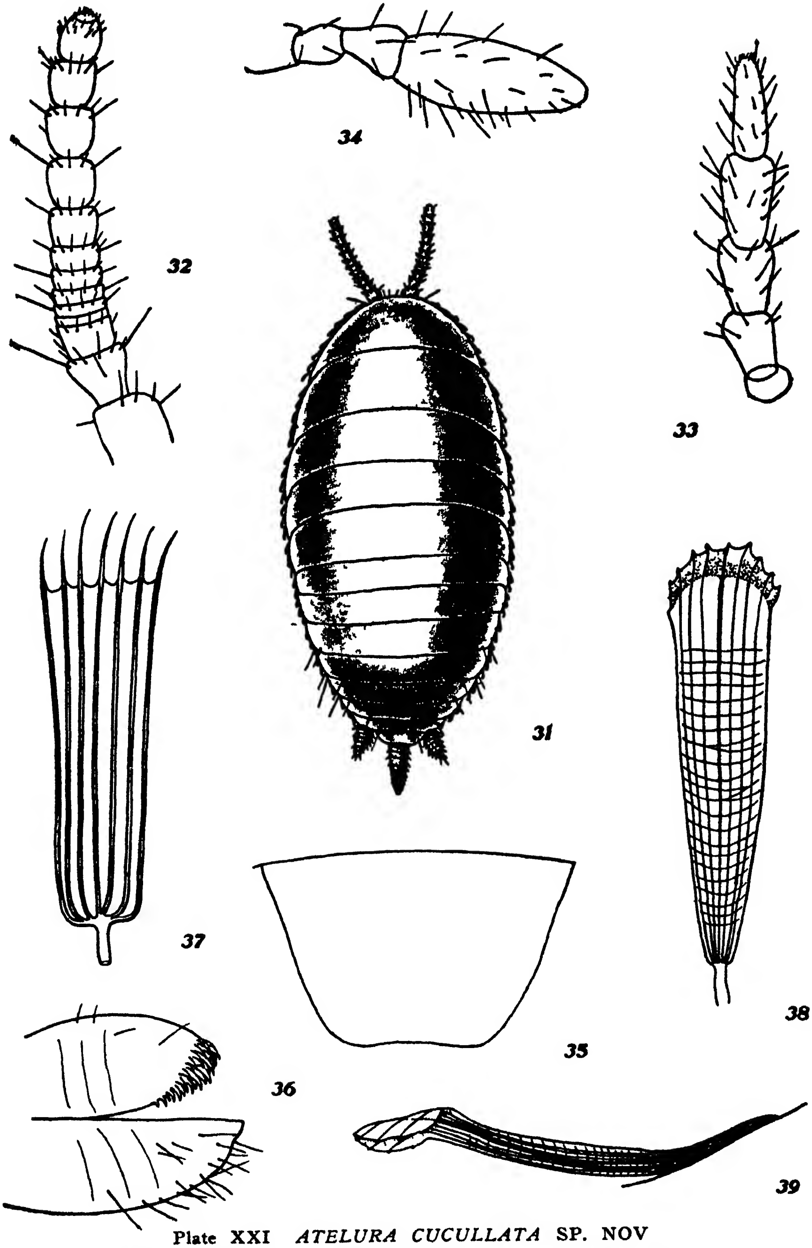


Plate XXI *ATELURA CUCULLATA* SP. NOV

31, dorsal aspect, X 17; 32, antenna, X 68; 33, maxillary palpus, X 85; 34, labial palpus, X 85; 35, tenth urotergite of female, X 85; 36, left aspect of ovipositor, X 86; 37, typical unmodified scale from dorsum, X 505; 38, modified scale from dorsum, dorsal aspect, X 505; 39, Modified scale from dorsum, lateral aspect, X 505.

last segment subconical, three times as long as broad. Labial palpi (fig. 34) with fourth segment three times as long as the third and lanceolate-elliptical, with length to breadth as 5:2. Tenth abdominal tergite (fig. 35) trapezoidal, with posterior border feebly emarginate and postero-lateral angles broadly rounded. Cerci short and stout; lateral cerci 8-segmented; pseudocercus ("median cercus") twice as long as the lateral cerci, 11-segmented. Posterior abdominal segments short, bringing the styli close together. Styli three pairs, on 7th to 9th abdominal segments, respectively. Ovipositor (fig. 36) with the ventral valves longer than the dorsal; both pairs segmented; dorsal valves with a terminal cluster of hooks. Dorsum of body without hairs, excepting a few stiff lateral hairs on the posterior abdominal segments (fig. 31). Dorsal scales dense, there being in each transverse series two types of scales, alternating with each other in position: the simple type shown in fig. 37 and a peculiar modified form (figs. 38, 39) in which the distal end is bent downward, forming a kind of hood. Length, 3.6 mm.

Two specimens, both females, Kartabo, Bartica District, British Guiana, September 9, 1920 (No. 321).

Atelura cucullata occurred with *Cornitermes pugnax* n. sp., which builds a nest close to the ground or under the ground, the nest being rather loosely constructed.

Nicoletia emersoni sp. nov.

(Plate XXII, figs. 40 to 48). (Plate XXIII, figs. 49, 50).

Pale yellow; appendages white. Campodeiform (fig. 40), five times as long as broad; body parallel-sided, the last four abdominal segments becoming successivly narrower. Thorax not broader than abdomen, from two-fifths to two-thirds as long as the latter. Head much longer than prothorax, with a median dorsal pentagonal sclerite (fig. 40). Eyes absent. Antennae long (incomplete in the specimens examined); first six segments (fig. 41) in relative lengths as 28:20:9:5:8:10; first segment large, subovate; second cylindrical. In one specimen the first 12 segments are simple (fig. 41) and each of

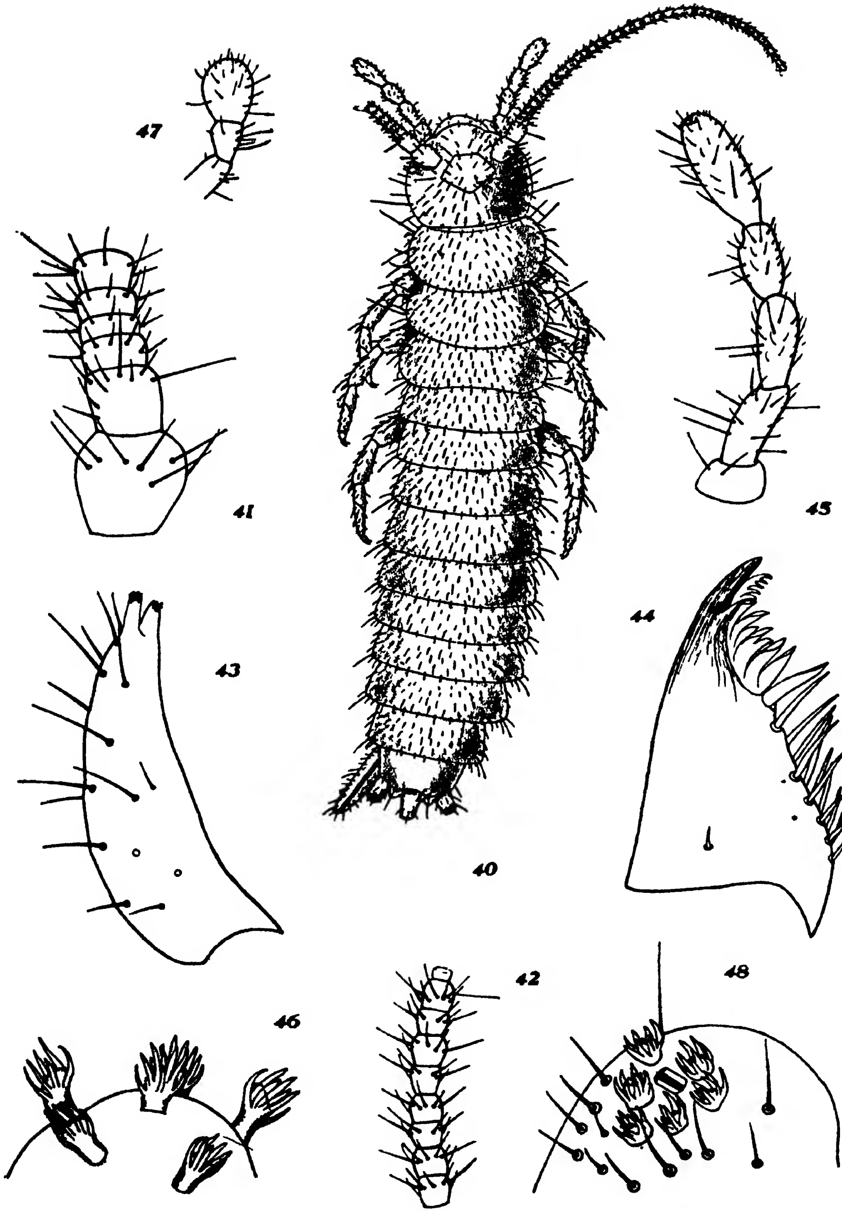


Plate XXII.

NICOLETTA EMERSONI SP. NOV.

40, dorsal aspect, X 25; 41, base of antenna, X 100; 42, distal segments of antenna, each primary segment being divided into two subsegments, X 100; 43, galea of right maxilla, ventral aspect, X 250; 44, lacinia of right maxilla, ventral aspect, X 250; 45, maxillary palpus, X 86; 46, apical sense organs of left maxillary palpus, X 677; 47, end of labial palpus, X 86; 48, subapical sense organs of left labial palpus, X 505.

the remaining 14 segments is divided into two equal subsegments (fig. 42), making apparently 40 segments in all; total number of segments unknown; second segment in male without a secondary sexual process. Galea maxilla (fig. 43) with a pair of terminal papillae. Lacinia (fig. 44) with large apical tooth, small inner subapical tooth, and an inner subapical comb, with series of inner teeth and setae as in fig. 44. Maxillary palpus with segments as in fig. 45; last segment subelliptical, three times as long as broad, with six apical branched sensory papillae (fig. 46), each consisting of a stalk bearing curving branches that surround a central sensory lobe. Last segment of labial palpus (fig. 47) clavate, two-thirds as broad as long, with a group of six distal sensory papillae (fig. 48) like those of the maxillary palpus except in being sessile. Tenth abdominal tergite in both sexes with a shallow median rounded emargination and rounded posterior lobes (fig. 49). Cerci and pseudocercus of unknown length (being broken off). Styli eight pairs, on the second to ninth abdominal segments, respectively; with accompanying eversible vesicles (fig. 50) except on the ninth segment. Ovipositor in form and length as in fig. 40. Parameres of male finger-like in form, each with a terminal seta (fig. 50). Clothing of dense short setae of irregular lengths, with long setae on the head, lateral borders of the thoracic segments, and postero-lateral angles of the abdominal segments. Length, 4 mm.

Nicoletia emersoni approaches *N. neotropicalis* Silvestri ('01*b*), from Argentine, Paraguay and Brazil, but differs from that species in having wider abdominal segments, and the pseudocercus of the male not narrower than the cerci, as well as in other respects. The first three segments of the maxillary palpus lack the spines shown in the figure by Escherich ('04) and the terminal sensory papillae of the maxillary palpus differ in form in the two species.

Two specimens, one of each sex, Penal Settlement, Bartica, March 24, 1919. Not termitophilous.

I take pleasure in naming this species after Mr. Alfred Emerson.

Borecus **gen. nov.**

Eyes and postantennal organs absent. Antennae short, but longer than the head, four-segmented, without subsegments or rings. Mouth parts biting. Prothorax reduced but not rudimentary. Mesonotum large but not produced over the base of the head. Fourth abdominal segment much longer than the third. Tibiotarsi two-segmented. Unguis with a pair of large inner basal lobes and a pair of smaller outer basal lobes, or pseudonychia. Unguiculus well developed, with a strong outer basal lobe. One tenent hair. Furcula strongly developed, appended apparently to the fifth abdominal segment. Manubrium longer than dentes. Dentes unsegmented, smooth dorsally, without crenulations or rings, and without chitinous hooks, but with two dorsal longitudinal series of large feather-like setae, and clothed ventrally with scales. Mucrones strongly elongate, non-lamellate, tomocerine in type but without the basal tooth, with a large apical tooth, a large subapical dorsal tooth, and a varying number of smaller dorsal teeth between the subapical tooth and the base of the mucro. Dens with an apical pair of long hyaline scales extending under the mucro. Clothing of both scales and setae, the latter mostly fringed and frequently clavate.

This new genus falls near the peculiar genus *Oncopodura,* described from the species *hamata,* from the Crimea, by Carl and Lebedinsky ('05), and represented also by a second species, *crassicornis* Shoebotham ('11) from England and Poland (Stach '21). *Oncopodura* is unlike *Borecus* in having the following differentiating characters: Postantennal organs present or absent. Prothorax rudimentary. Fourth abdominal segment slightly longer than the third. Unguis simple, without inner teeth, without pseudonychia, and without large inner basal lamellae, though narrow pointed lateral lamellae may or may not be present. Unguiculus simple, without teeth or lobes. Tenent hairs absent immediately above the unguis, but a strong clavate hair projects from the tibiotarsus about midway from the base to the apex on the second pair of legs only. Dentes with chitinous hooks, with slender fringed hairs dorsally, but

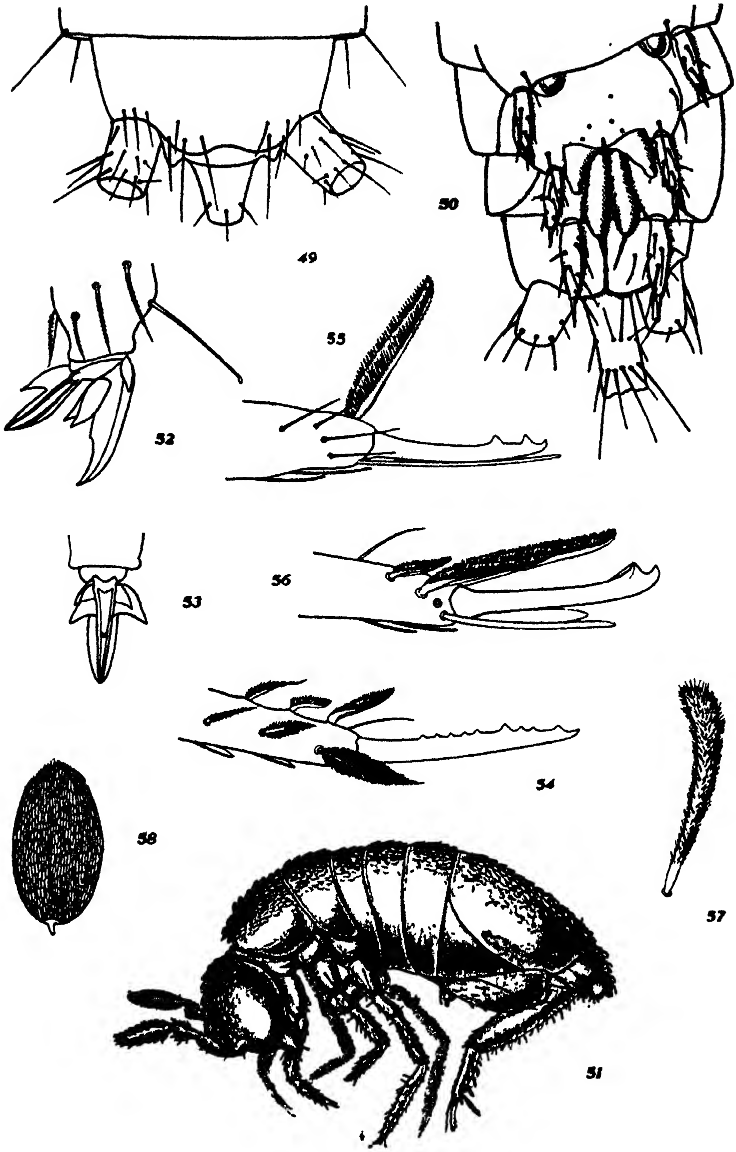


Plate XXIII.

NICOLETIA EMERSONI SP. NOV. *BORECUS PINNATUS* GEN. ET SP. NOV.

NICOLETIA EMERSONI.—49, dorsal aspect of tenth urotergite of female, X 70; 50, ventral aspect of male to show parameres and last three pairs of styli, X 88.

BORECUS PINNATUS.—51, lateral aspect, X 68; 52, right hind foot, X 632; 53, concave aspect of left hind unguis, X 632; 54, left aspect of right mucro and end of dens, X 380; 55, left aspect of left mucro and end of dens, X 588; 56, left aspect of left mucro and end of dens, X 404; 57, dorsal clavate fringed seta from base of dens, X 1008; 58, typical scale from dorsum, X 648.

without broad pinnate setae. Mucro with a well developed hyaline membrane, or lamella.

The genus *Borecus* may be placed with *Oncopodura* in the subfamily Oncopodurinae of the family Entomobryidae. The affinities of *Oncopodura* lie with *Cyphoderus*, as Stach ('21) has pointed out.

Borecus pinnatus gen. et sp. nov.

(Plate XXIII, figs. 51 to 58).

White throughout (fig. 51). Eyes and postantennal organs absent. Antennae longer than the head, varying from slightly longer (in small specimens) up to 1.5 times as long as the head (large specimens); four-segmented, without subsegments; antennal segments varying greatly in relative lengths, but with third segment always much shorter than the second or the fourth; first segment cylindrical; second clavate, becoming subcylindrical with age; third clavate; fourth subconical, elongating with age; third segment with a subapical pair of elliptico-cylindrical sensory pegs lying exposed, not covered by an integumentary fold; fourth segment distally with short curving sensory setae; antennal clothing of abundant short minutely fringed setae, with occasional outstanding simple setae. Mouth parts biting. Prothorax reduced. Mesonotum rounded anteriorly, covering the prothorax, the latter abnormally exposed in fig. 51, but not projecting over the base of the head. Metanotum two-thirds as long as mesonotum. Tibiotarsi with a transverse suture one-third from the apex; femora with a transverse suture near the apex; these sutures not always evident, however. Legs clothed with abundant fringed setae, with one (occasionally two) long stout outstanding fringed setae on each segment of each leg. Unguis (figs. 52, 53) straight basally, curving apically, with a pair of large inner basal sublanceolate lobes extending half the length of the claw; with a pair of smaller basal lateral lanceolate lobes (pseudonychia); and with an obscure tooth (doubled?) or angle near the middle of the inner margin. Unguiculus (fig. 52) large, extending three-fourths as far as the unguis, with a large basal subovate acuminate outer lobe. Hind claws the

largest. Tenent hair single, feebly knobbed. Ventral tube with a pair of eversible rounded vesicles. Fourth abdominal segment much longer than the third, varying in relative length but usually from three to five times as long as the latter. Rami of tenaculum quadridentate; corpus with a single ventral seta. Furcula apparently appended to the fifth abdominal segment, attaining the ventral tube in the larger specimens, but not in the smaller. Manubrium elongate, scarcely tapering; dorsally with many setae, either simple, or clavate and fringed; ventrally with scales. Dentes two-thirds as long as manubrium, slightly tapering, one-segmented, smooth dorsally, without crenulations or rings, with two dorsal rows of large pinnae, or feather-like setae (figs. 54-56) which, proceeding posteriorly, become successively larger. The setae of the outer series are 5-10 in number (according to age), the proximal one, two, or more setae being relatively simple and the remainder modified. The setae of the inner series are 4-7, the proximal one or two being simple, and the last of the pinnate setae (subapical) being exceptionally long (figs. 55, 56), sometimes a little longer than the mucro. At the base of the dens dorsally is a stout clavate erect fringed seta (fig. 57). Under the mucro are two long, narrowly elliptical, hyaline, minutely striated scales (figs. 55, 56), one of which may extend beyond the mucro; these scales arising near the apex of the dens. Each dens bears a lateral row of 4-15 simple or feebly fringed setae; ventrally the dentes are clothed with scales. Mucrones (figs. 54-56) one-half to three-fifths as long as the dentes, slender and tapering in dorsal aspect, in form much like those of *Tomocerus*, with a large apical tooth, usually hooked, and a dorsal subapical tooth subequal to the first. Between the base of the mucro and the subapical tooth is a dorsal row of small intermediate teeth (fig. 54), one of which is larger than the others. These intermediate teeth may, however, be absent, as in fig. 56, and when present vary in number from 1 to 11. Mucronal lamellae are absent, excepting in some specimens a minute lamella extending forward from the anteapical tooth as in fig. 56. The scales that clothe the head and body dorsally differ in size and vary in form from elliptical to oval, ovate or roundish, but are commonly elliptical, as in fig. 58. Fringed setae occur on

the head anteriorly, on the fourth abdominal segment posteriorly, and on the fifth and sixth abdominal segments, many of the setae on the genital and anal segments being strongly clavate. Length of specimens, 0.54 mm. to 1 mm.

This species varies considerably, some of the variation being correlated with the age of the individual (as indicated by its size), and some being independent of age. The dorsal setae of the dentes increase in number with the age of the individual, and more of them become pinnately modified. In several small specimens, 0.54 mm. to 0.87 mm. in length, the dorsal intermediate teeth of the mucrones were absent; in one individual, 0.9 mm. in length, there was one of these teeth on each mucro; in five specimens, all 1 mm. long, the number of intermediate teeth varied from one to eleven.

Fifteen specimens, Kartabo, Bartica District, British Guiana, June 21, 30, July 13, 30. (Field Nos. 57, 87, 92, 101.)

Hosts.—Rhinotermes (*R.*) *marginalis* (*L.*), *Nasutitermes* (*N.*) *costalis* (Holmgren), *Nasutitermes* (*N.*) *octopolis* Banks, *Nasutitermes* (*N.*) *acajutlae* (Holmgren).

Borecus pinnatus was with four species of termites: *Nasutitermes* (*N.*) *octopilis* Banks, *costalis* (Holmgren), *acajutlae* (Holmgren); *Rhinotermes* (*R.*) *marginalis* (Linné). All but the last of these species build conspicuous, well formed nests above ground.

Mr. Emerson reports that this collembolan was found very often in large numbers in nests, and says, "I think it very likely that the same species is found outside of termite nests, but found one striking illustration of their true association with the termites. One morning I found an entire termite colony of the species *Nasutitermes* (*N.*) *costalis* (Holmgren) migrating over a sandy stretch of ground. The king and queen termites in addition to the workers and soldiers were all going along in a long file from a clump of bamboos to our dwelling. In addition to numerous other guests found among the termites, springtails were also running along the trail and were undoubtedly migrating with the termite colony. To my mind, this is a

conclusive proof that the springtails have a distinct liking for life among the termites. They run rapidly about among the termites in the nests and I have never observed any hostile action toward them on the part of the termites. They are also pantermitophilous, as illustrated by the different host species, and in the case where they were found associated with *Rhinotermes* (*R.*) *marginalis* (Linné) there was no particualr nest, the termite colony being very small. It therefore seems to me that the association of the Collembola with the termites is rather more loose than is the case with the species of *Atelura* and most other synoeketes, and it is highly probable that they are not entirely dependent upon the termites for their existence."

BIBLIOGRAPHY

CARL, J., AND LEBEDINSKY, J.

1905. Materialen zur Höhlenfauna der Krim. II. Aufsatz. Ein neuer Typus von Höhlenapterygoten. Zool. Anz., vol. 28, pp. 562-565, figs. 1-6.

ESCHERICH, K.

1904. Das System der Lepismatiden. Zoologica, Heft 43, 164 pp., 4 pls., 67 figs.

JANET, C.

1896*a*. Sur les rapports des Lépismides myrmécophiles avec les Fourmis. Comptes rend. Séances Acad. Sc., vol. 122, pp. 799-802, 1 fig.

1896*b*. Sur les Lepismina polypoda, Grassi, et sur ses rapports avec les Fourmis. Bull. Soc. Ent. France, pp. 131-138.

SHOEBOTHAM, J. W.

1911. Some Records of Collembola New to England, with Description of a New Species of Oncopodura. Ann. Mag. Nat. Hist., ser. 8, vol. 8, pp. 32-39, pl. 3.

SILVESTRI, F.

1901*a*. Descrizione di nuovi Termitofili e relazioni di essi con gli ospiti. Boll. Mus. Zool. Anat. comp. Univ. Torino, vol. 16, pp. 1-24.

1901*b*. Materiali per lo Studio dei Tisanuri. Bull. Soc. Ent. Ital. vol. 33, pp. 204-249, figs. 1-48.

STACH. J.

1921. Vorarbeiten zur Apterygoten-Fauna Polens. Teil II. Apterygoten aus den Pieniny. Bull. Acad. Polonaise Sc. Lett. (1919), pp. 133-233, pls. 5-7.

ON THREE APPARENTLY NEW SPECIES OF TERMITAPHIS (Hem. Het.)[1] *

By HAROLD MORRISON[2]

Bureau of Entomology, Department of Agriculture, Washington, D. C.

(Plate XXIV)

The following new species of *Termitaphis* were received for study from Dr. W. M. Mann, to whom they had previously been sent for examination by Dr. Alfred Emerson of the University of Pittsburgh.

The genus *Termitaphis* was first established by Wasmann[3] in 1902, but was not accurately characterized until 1911, when Silvestri[4] described two new members of the genus, presented a critical generic diagnosis and erected a new family in the suborder Heteroptera for its reception. Later, Mjöberg[5] gave a short description of a species obtained in Australia, with the promise to describe it in greater detail at some future date. This extended description has apparently never been published, and the original characterization is too brief to permit a comparison of Mjöberg's species with those described below.

Wasmann's species was obtained in Columbia, and the first species described below may possibly be identical with it, although this cannot be definitely established on account of the incompleteness of the description of the genotype and the probable inaccuracy of the figures given by Wasmann. It has accordingly been described as new.

* Tropical Research Station, Contribution Number 140.

[1] Tropical Research Station, Contribution Number 140.

[2] The figures illustrating the structural characteristics of these species have been worked out and prepared by Emily Morrison.

[3] Wasmann, E. Species novae Insectorum Termitophilorum ex America Meridionali. In Tidj. voor Ent. vol. 45, 1902, pp. 95-107, 9 pl.

[4] Silvestri, F. Sulla Posizione Sistematica del Genera Termitaphis Wasm. (Hemiptera), etc. In. Boll. del Lab. di Zool. Gen. e. Agraria della. Rsc. Sup. d'Agr. in Portici. vol. 5, 1911, pp. 231-236, fig. I-VI.

[5] Mjoberg, E. Preliminary description of a new representative of the family Termiticorddae Silv. In Entomologisk Tidskrift, etc. vol. 35, 1914, p. 98, 9 fig.

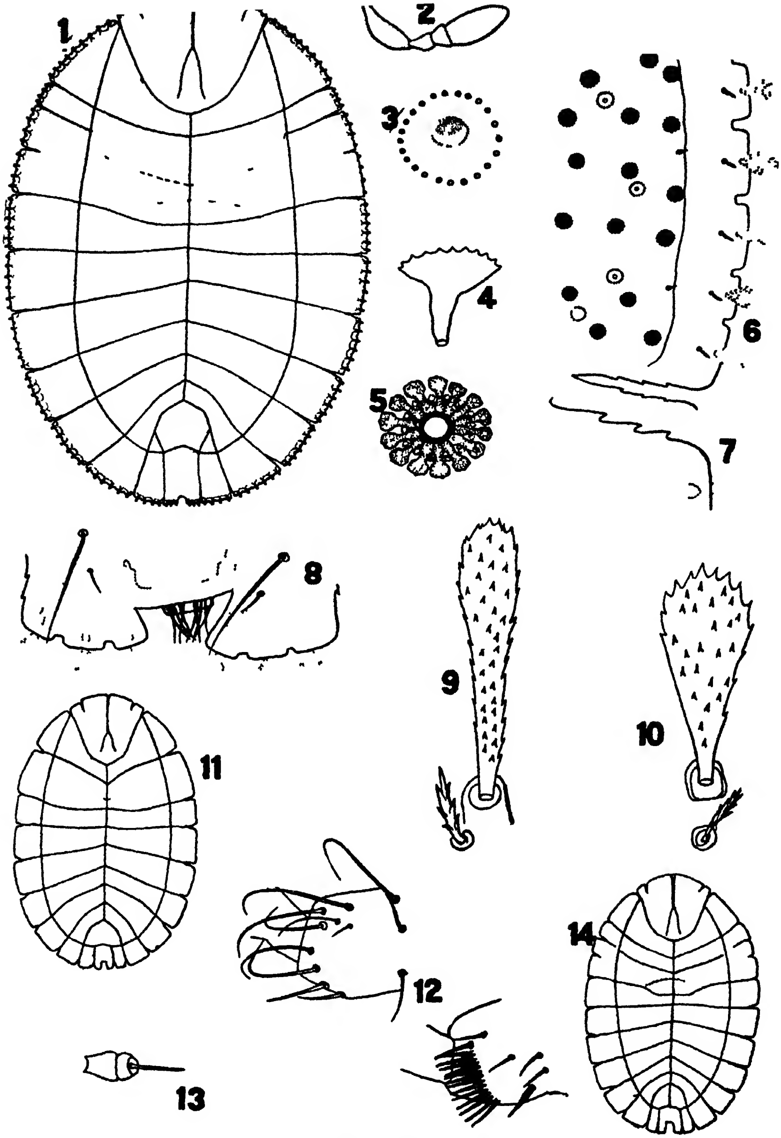


Plate XXIV

TERMITAPHIS GUIANAE SP NOV *T INSULARIS* SP NOV
T TRINIDADENSIS SP NOV

T GUIONAE—1, outline of body showing shape, lobes and sultures, dorsal X30, 2, antenna, X57 5, 3 dorsal pore, X1280, 4, dorsal pore, second type side view, X1280; 5, same as 4, view from above, X1280, 6, marginal lobe of abdominal segment, dorsal, X220; 7, portion of 6 ventral view, X440, 8, apical abdominal lobes with anal opening ventral, X220; 13, dorsal seta, X1280,

T INSULARIS—9, marginal flabellum, X640, 11, outline showing marginal lobes and sutures, dorsal, X17 5

T TRINIDADENSIS—10, marginal flabellum, X1280; 12, apex of anterior tibia, two sides, X220; 14, outline of body showing marginal lobes and sutures, dorsal, about X17.5.

Termitaphis guianae sp. nov.

(Plate XXIV, Figures 1 to 14)

Very similar to *T. mexicanus* as described by Silvestri, differing only in certain details: length 2 mm. width 1.44 mm., arrangement of the dorsal sutures, particularly the anterior pseudo-suture of the mesothorax, differing somewhat from that shown in Silvestri's drawing (cf. fig. 1 with fig. III of Silvestri's paper); the fourteen marginal lobes of each half of the body bearing tubes and flabella as follows, counting from the cephalic apex: 7, 3 (head); 9-10 (prothorax); 4, 4 (mesothorax); 4-5 (metathorax); 5-6, 6, 6-7, 6-7, 6, 6, 4, 3 (abdomen) the usual number for each prothorax lobe being nine, for each mesothoracic lobe, four, and for each metathoracic and abdominal lobe, anterior to the last two, six, differing in these from *mexicanus* where the usual number for the mesothoracic lobes is five, for the anterior abdominal lobes, seven, and for apical abdominal lobes, two instead of three flabella; these flabella with minute setae or denticulae over the entire surface as well as along margin and with similar minute setae very numerous on the lobes; lateral margins of each lobe conspicuously serrate, not smooth; derm pores of two sorts, some simple cylindrical tubes surrounded by a circular clear area, and with a funnel-shaped opening, others with an intricate radiate arrangement; with occasional stout setae dorsally, each set at the end of a tube through the derm; with two larger thoracic and six well developed but smaller circular abdominal spiracles followed by an incompletely developed seventh abdominal spiracle; anterior legs in addition to curved hairs and some stiff spines with a straight comb of long stiff hairs at apex of tibia; other characteristics, so far as can be observed, agreeing very closely with those of *mexicanus* as described and figured by Silvestri.

This species has been described from three specimens with the following information:

Kartabo, British Guiana, No. 48. Emerson.

Host.—Leucotermes crinitus (Emerson).

HOLOTYPE.—(A slide mount) and paratypes. Cat. No. 25034, U. S. National Museum.

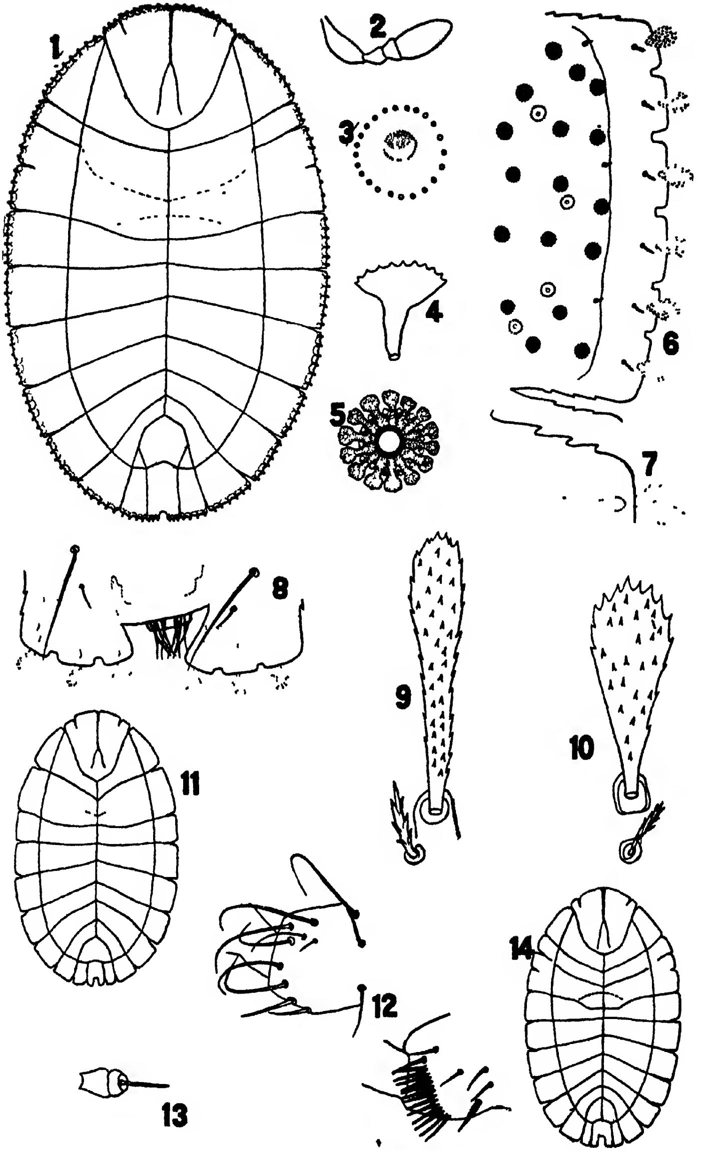


Plate XXIV.

TERMITAPHIS GUIANAE SP NOV., *T INSULARIS* SP NOV, *T. TRINIDADENSIS* SP NOV

T. GUIONAE.—1, outline of body showing shape, lobes and sultures, dorsal X30; 2, antenna, X57 5; 3, dorsal pore, X1280; 4, dorsal pore, second type side view, X1280; 5, same as 4, view from above, X1280; 6, marginal lobe of abdominal segment, dorsal, X220; 7, portion of 6 ventral view, X440; 8, apical abdominal lobes with anal opening ventral, X220; 13, dorsal seta, X1280;

T. INSULARIS.—9, marginal flabellum, X640, 11, outline showing marginal lobes and sutures, dorsal, X17 5.

T. TRINIDADENSIS —10, marginal flabellum, X1280; 12, apex of anterior tibia, two sides, X220; 14, outline of body showing marginal lobes and sultures, dorsal, about X17.5.

Termitaphis guianae sp. nov.

(Plate XXIV, Figures 1 to 14)

Very similar to *T. mexicanus* as described by Silvestri, differing only in certain details: length 2 mm. width 1.44 mm., arrangement of the dorsal sutures, particularly the anterior pseudo-suture of the mesothorax, differing somewhat from that shown in Silvestri's drawing (cf. fig. 1 with fig. III of Silvestri's paper); the fourteen marginal lobes of each half of the body bearing tubes and flabella as follows, counting from the cephalic apex: 7, 3 (head); 9-10 (prothorax); 4, 4 (mesothorax); 4-5 (metathorax); 5-6, 6, 6-7, 6-7, 6, 6, 4, 3 (abdomen) the usual number for each prothorax lobe being nine, for each mesothoracic lobe, four, and for each metathoracic and abdominal lobe, anterior to the last two, six, differing in these from *mexicanus* where the usual number for the mesothoracic lobes is five, for the anterior abdominal lobes, seven, and for apical abdominal lobes, two instead of three flabella; these flabella with minute setae or denticulae over the entire surface as well as along margin and with similar minute setae very numerous on the lobes; lateral margins of each lobe conspicuously serrate, not smooth; derm pores of two sorts, some simple cylindrical tubes surrounded by a circular clear area, and with a funnel-shaped opening, others with an intricate radiate arrangement; with occasional stout setae dorsally, each set at the end of a tube through the derm; with two larger thoracic and six well developed but smaller circular abdominal spiracles followed by an incompletely developed seventh abdominal spiracle; anterior legs in addition to curved hairs and some stiff spines with a straight comb of long stiff hairs at apex of tibia; other characteristics, so far as can be observed, agreeing very closely with those of *mexicanus* as described and figured by Silvestri.

This species has been described from three specimens with the following information:

Kartabo, British Guiana, No. 48. Emerson.

Host.—Leucotermes crinitus (Emerson).

HOLOTYPE.—(A slide mount) and paratypes. Cat. No. 25034, U. S. National Museum.

Termitaphis trinidadensis **sp. nov.**

Very similar to the preceding, size almost identical, length 2 mm., width 1.5 mm., the chief differences being found in the somewhat more elongate and more slender marginal flabella and in the different numbers of marginal flabella for corresponding lobes of the body, the arrangement of these being as follows: 7:3 (head); 8 (prothorax); 4, 4 (mesothorax); 3-4 (metathorax); 4, 4, 4, 4, 4, 4, 4, 3 (abdomen).

This species has been characterized from a single specimen with the following information:

"Port-of-Spain, Trinidad. 26-XI-20. Emerson. No. 495a."

Host.—*Leucotermes tenuis* (Hagen).

HOLOTYPE.—(A slide mount). Cat. No. 25035. U. S. Nat. Museum.

Termitaphis insularis **sp. nov.**

Body somewhat more elongate than in the two preceding species, length, 2.75 mm.; width, 1.6 mm.; legs more elongate and more slender than with the last, more nearly resembling those of *T. guianae;* differing conspicuously from all the other accurately described species in that the body has only 12 lobes on each half and from the two preceding species in the much more elongate and slender marginal flabella, these resembling those of *T. subafra* Silvestri; the arrangement of these flabella as follows: 7, 3 (head); 10-11 (prothorax); 11 (meso and metathorax); 6, 7-8, 6-7, 7, 7, 6, 4, 3 (abdomen), the fusion occurring in the meso and metathoracic lobes, usually three on each side; in other respects quite similar to the two species already described.

Characterized from a single specimen with the following information:

"Port-of-Spain, Trinidad. 26, XI, 20. Emerson. No. 495a."

Host.—*Leucotermes tenuis* (Hagen).

HOLOTYPE.—(A slide mount). Cat. No. 25036. U. S. Nat. Museum.

There may be seen in the posterior portion of the abdomen of the specimen on which this species is based, some curled and twisted tubes and some other less definite, apparently chitinized structures which suggest themselves as possibly retracted male sexual organs. No definitely developed copulatory or other external sexual modifications of the apex of the abdomen, such as are to be found in many of the Heteroptera, have been noted in these specimens, and nothing appears to be known regarding the differences in sexes in the genus. Since the last two species described were received in the same container, and were collected from the same nest of termites, the further possibility presents itself that they are the two sexes of one species, although the obvious differences in certain of the comparable structural characters fully justifies their separation at this stage of our knowledge of these insects.

By way of comment, it may be noted that the writer's interpretation of the body segmentation differs from that given by Silvestri in his generic diagnosis and in his figures of both *mexicanus* and *subafra.* In both species Silvestri shows a total of fourteen lobes for each half of the body of which two are allotted to the head, two to the prothorax, two to the mesothorax, one to the metathroax, and one each to five complete and two incomplete abdominal segments. It would appear that Silvestri failed to observe the anterior thoracic spiracles, located close to each prothoracic coxa, and highly probable that his specimens actually possess a partially suppressed seventh abdominal spiracle, as do all of those examined in connection with the preparation of the preceding descriptions.

These two additions give a total of nine more or less developed spiracles for the genus, instead of seven as given by Silvestri, of which the two anterior are slightly but distinctly larger and appear to be placed at the anterior margins of the under surface of the meso and metathorax, leaving seven pairs for the abdomen and resulting in a reassignment of the marginal lobes of those species having fourteen lobes to each half of the body as follows: two to the head; one to the prothorax, two to the mesothorax, one to the metathorax, and eight to the abdomen.

Silvestri's key to the species of this genus may be modified as follows to include the newly described species:

a. Flabella of marginal lobes simple entire setae[6] *circumvallata* Wasm.

aa. Flabella of marginal lobes broader, spatulate, margins minutely serrate.

- *b.* Margin of body with fourteen lobes to each half.
  - *c.* Marginal flabella short and broad, at most hardly more than twice as long as wide.
    - *d.* Apical abdominal segments with two flabella on each lobe; anterior abdominal segments normally with seven flabella on each margin *mexicanus* Silv.
    - *dd.* Apical abdominal segments with three flabella on each lobe; anterior abdominal segments normally with six or fewer flabella on each margin.
      - *e.* Anterior abdominal segments normally with six flabella on each margin; legs relatively slender.......... *guianae,* sp. nov.
      - *ee.* Anterior abdominal segments normally with four flabella on each margin; legs relatively short and stout.......... *trinidadensis,* sp. nov.
  - *cc.* Marginal flabella elongate, slender, the length much more than twice the width.......... *subafra* Silv.
- *bb.* Margin of body with twelve lobes to each half; flabella elongate.......... *insularis,* sp. nov.

[6] Based only on figures and description of Wasmann.

ON FOUR TERMITOPHILOUS MILLIPEDS FROM BRITISH GUIANA*

By Ralph V. Chamberlin

(Plates XXV, XXVI, XXVII)

The types of the new millipeds here described were taken by Mr. Alfred Emerson from nests of termites at Kartabo, Bartica District, British Guiana, in December, 1919, and August, 1920. All three pertain to the Cryptodesmidae in the broad sense, a group of mostly very small polydesmoid forms which in tropical regions appear to be rather numerous and widespread although commonly overlooked because of their small size and obscure habits. A number of species have previously been reported as occurring in termite nests and others in ant nests.

Leuritus gen. nov.

Body consisting of the head and twenty segments.

Head concealed from above by the collum which projects widely beyond it. Antennae moderately long, with the fifth joint much longer than the sixth.

Collum with a broad horizontal border which is divided by radial sulci into twelve lobes. Central region of collum moderately convex and tubercular.

The keels of the succeeding tergites wide and horizontal, the lateral border divided into three areas by radial sulci excepting the fifth, which shows two, and the most caudal ones, which show a fourth lobe in some degree developed. The poriferous keels in respect to lobation not differing from the non-poriferous. Repugnatorial pores minute, situated near caudalateral corner of keels of segments V, VII, XI, X, XII, XIII, and XV to XIX; pores not opening on special cones or lobes and detected with difficulty. Tergites between keels bear-

* Tropical Research Station, Number 141.

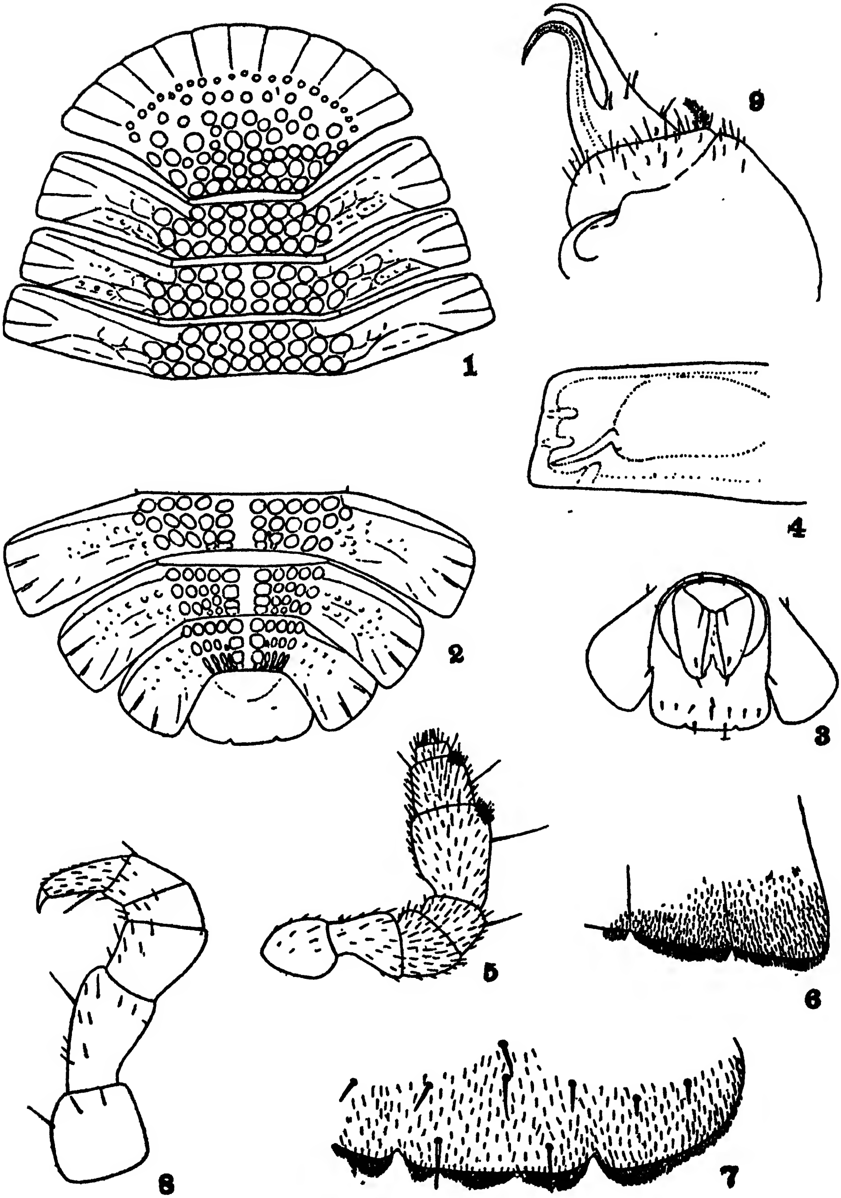


Plate XXV.

GASATOMUS EMERSONI SP. NOV., *TIDOTERUS SEQUENS* SP. NOV.

1, the four anterior tergites from above; 2, the four posterior tergites from above; 3, caudal end of body from below; 4, keel of thirteenth segment cleared and view by transmitted light to show the course of the repugnatorial duct; 5, antenna; 6, portion of collum more highly magnified to show hairs; 7, caudal portion of anal tergite from below under higher magnification to show hairs and setae; 8, a leg; 9, a gonopod of male in subcaudal view.

ing three transverse rows of tubercles, none of them specially enlarged to form more prominent longitudinal series.

Last tergite broad, flat, rounded behind, the margin tri-lobed; widely surpassing the anal valves.

Second article of legs longer than the third and than the sixth.

Gonopods of male with the basal joint enlarged as usual, but the telopodite extending beyond it and clearly exposed. The telopodite deeply furcate, the two branches slender, smooth and curved.

Genotype.—*Leuritus termitophilus* sp. nov.

In the general form and proportions of the collum and keels much resembling the West Indian genus Tridesmus; but the posterior lobes of the poriferous keels are not at all en-larged as in that genus and the caudal tergite is broad and rounded instead of triangular. It is also quite distinct in the structure of the gonopods.

Leuritus termitophilus sp. nov.

(Plate XXV, Figures 1 to 7)

General color flavous, often appearing in part brownish because of adherent foreign material. Surface of tergites densely clothed with very short hairs which are evident par-ticularly on borders of keels and collum. (Cf. pl. XXV, figs. 6 and 7.)

The head is compressed dorsoventrally and presents a sharp transverse edge across vertex and down each side. Sulcus sharply impressed across vertex, furcate below, sending a branch to base of each antenna. A deep groove on each side of the head above into which the basal articles of the antenna fit. Labral margin with three teeth.

Fifth joint of antennal article about two-thirds as thick as long and twice as long as the sixth article. (Cf. pl. XXV, fig. 5.)

Collum depressed, broad; rim broad, with deep radial sulcis, but with the corresponding marginal notches slight; surface within the border tubercular. (Pl. XXV, fig. 1.)

On the keels of the following tergites in general the anterior border is elevated; the lateral lobes indicated by radial furrows but the marginal notches slight or obsolete. Dorsum of tergites between keels densely tubercular, the tubercles not unequally developed in a way to leave longitudinal series of more prominent ones; tubercles in general in three transverse rows on each tergites; the tubercles form also longitudinal rows which on each tergite tend to run ectad of directly forward from caudal end. (Pl. XXV, figs. 1 and 2.) The course of the duct from the repugnatorial gland to the pore is indicated in pl. XXV, fig. 4.

The anal tergite with caudal margin broad, at middle nearly straight, the lateral corners rounded; sides subparallel; surface clothed with very fine short hairs; on ventral surface a transverse series of seven short setae, with two on median lobe caudad of these and one cephalad of them. (Cf. pl. XXV, figs. 3 and 7.)

The gonopods of the male as represented in pl. XXV, fig. 9.

Length, 4.5 mm.; width, 1.5 mm.

Locality.—British Guiana, Kartabo, Bartica District, Aug. 16, 1920. Fifteen specimens, some of which are only partly grown, taken from the nest of *Nasutitermes* (*Nasutitermes*) *brevipilus* (Emerson).

Stenitus gen. nov.

Consisting of the head and twenty segments.

Fifth joint of antennae much exceeding the sixth.

Collum high and convex, with sides steep; the rim depressed and descending almost in line with the sides above it, narrow, with ten areas separated by radial sulci.

Keels of tergites in general short and bent downward, the lateral border of the keels of the second tergite showing three

areas or lobes separated by sulci, the succeeding ones showing only two. Tergites between keels tubercular, the tubercles forming distinct longitudinal rows of which one a little each side of middle and one on each side are higher or more prominent, especially on the more posterior tergites; three tubercles in each row on each segment. Repugnatorial pores minute as in Leurodesmus, situated toward posterior lateral corner on segments V, VII, IX, X, XII, XIII, and XV to XIX inclusive.

Anal tergite large and freely exposed, caudally well rounded.

Second joint of legs longer than second and than sixth.

Genotype.—*S. guiananus* sp. nov.

Stenitus guiananus sp. nov.

(Plate XXVI, Figures 1 to 8)

General color flavous.

Median sulcus across vertex of head deep, furcate below, a branch running to each antennal socket. Vertex protruding each side of sulcus and densely granular. Head with a furrow on each side for the reception of the basal joints of the antennae. Fifth joint of antennae less than two times longer than wide and between four and five times longer than the sixth joint. (Pl. XXVI, fig. 7.)

Collum strongly tubercular excepting over the rim. Rim strongly depressed, the radial lines distinct, the corresponding marginal notches not deep.

Keels of the second tergite with marginal notches weakly developed; the notches scarcely evident on following keels when viewed at right angles to their surface, but when viewed obliquely the radial furrow may give the appearance of a marginal notch. Cf. pl. XXVI, figs. 1, 2 and 3.) Four rows of tubercles along the dorsum more prominent, particularly the two submedian ones; two rows of smaller tubercles between each two more prominent rows.

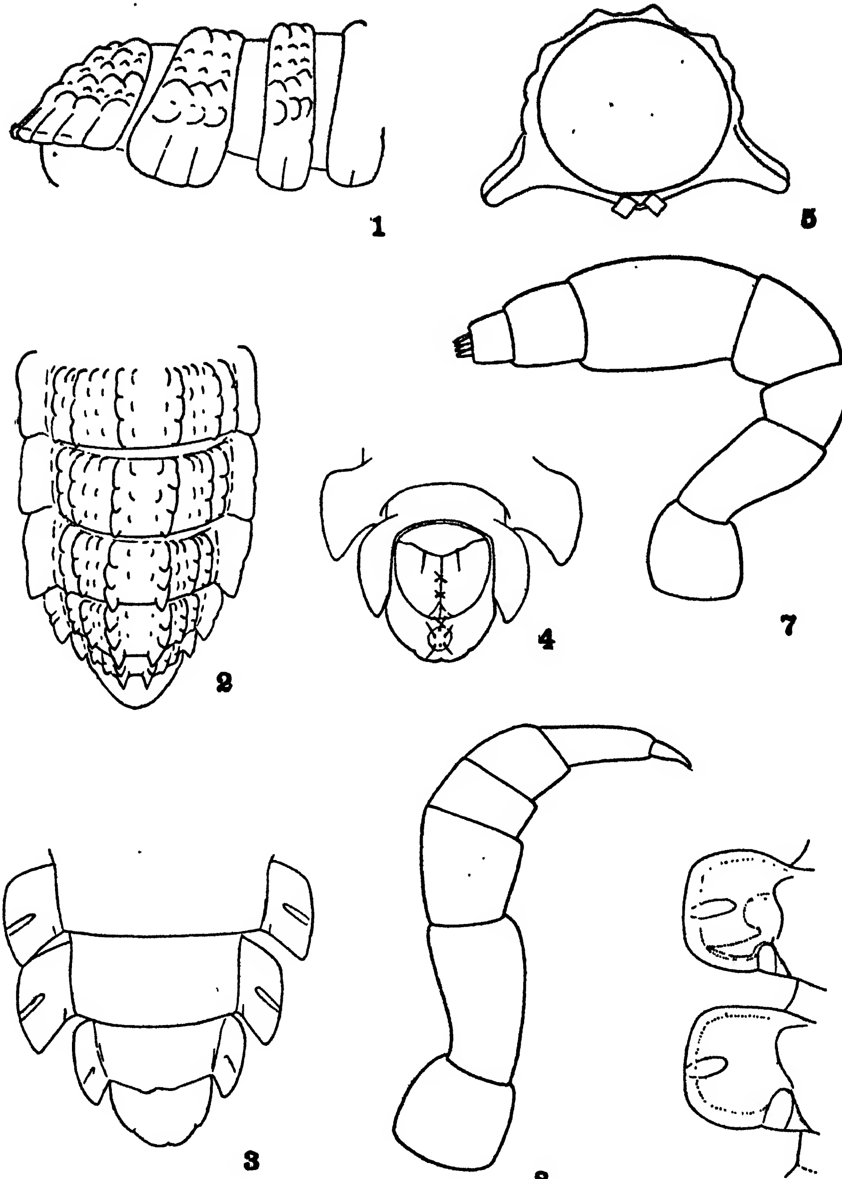


Plate XXVI.

STENITUS GUIANANUS SP. NOV.

1, anterior tergites in lateral view; 2, posterior tergites, dorsal view; 3, posterior end of another specimen in outline, with tergites depressed to bring keels into a more nearly horizontal position; 4, caudal end, ventral view; 5, sixth segment, anterior view, in outline; 6, tenth and eleventh keels viewed at right angles to surface; with course of repognatorial duct indicated on the tenth by dotted line; 7, antenna in outline; 8, a leg in outline.

The anal tergite much exceeding the nineteenth, caudally rounded, the margin notched at median line and on each side as shown in pl. XXVI, fig. 4.

Proportions of joints of legs as shown in pl. XXVI, fig. 8.

Length, 4.4 mm.; width, 7 mm.

Locality.—British Guiana, Kartabo, Bartica District. One adult female, all but the four anterior segments of another, and three immature specimens taken Aug. 16, 1920, from a nest of *Nasutitermes* (*Nasutitermes*) *brevipilus* (Emerson).

Gasatomus gen. nov.

Consisting of the head and twenty segments.

Head completely covered by the collum. Fifth joint of antennae much exceeding the sixth in length.

Border of collum nearly horizontal; divided by radial furrows into twelve areas or lobes, with corresponding marginal notches or crenations. Collum within the border convex and strongly tubercular.

Keels of succeeding tergites of moderate length; presenting laterally three lobes or areas separated by sulci and corresponding marginal incisions excepting the fifth, which have but two lobes, and the seventeenth, eighteenth, and nineteenth, which have four. Each repugnatorial pore opening at the apex of a special and prominent process projecting laterad from the posterior lobe. Pores present on segments V, VII, IX, X, XII, XIII, XV and XVI. Posterior margin of keels incised.

Last tergite freely exposed; much exceeding the processes of the nineteenth keels; with six marginal lobes or crenations.

Second joint of legs longer than the third and than the sixth.

Genotype.—*G. emersoni* sp. nov.

Much suggesting Çynedesmus, a genus known from Central America, the West Indies, and the Canary Islands. From that genus it differs clearly in the lobation of the keels.

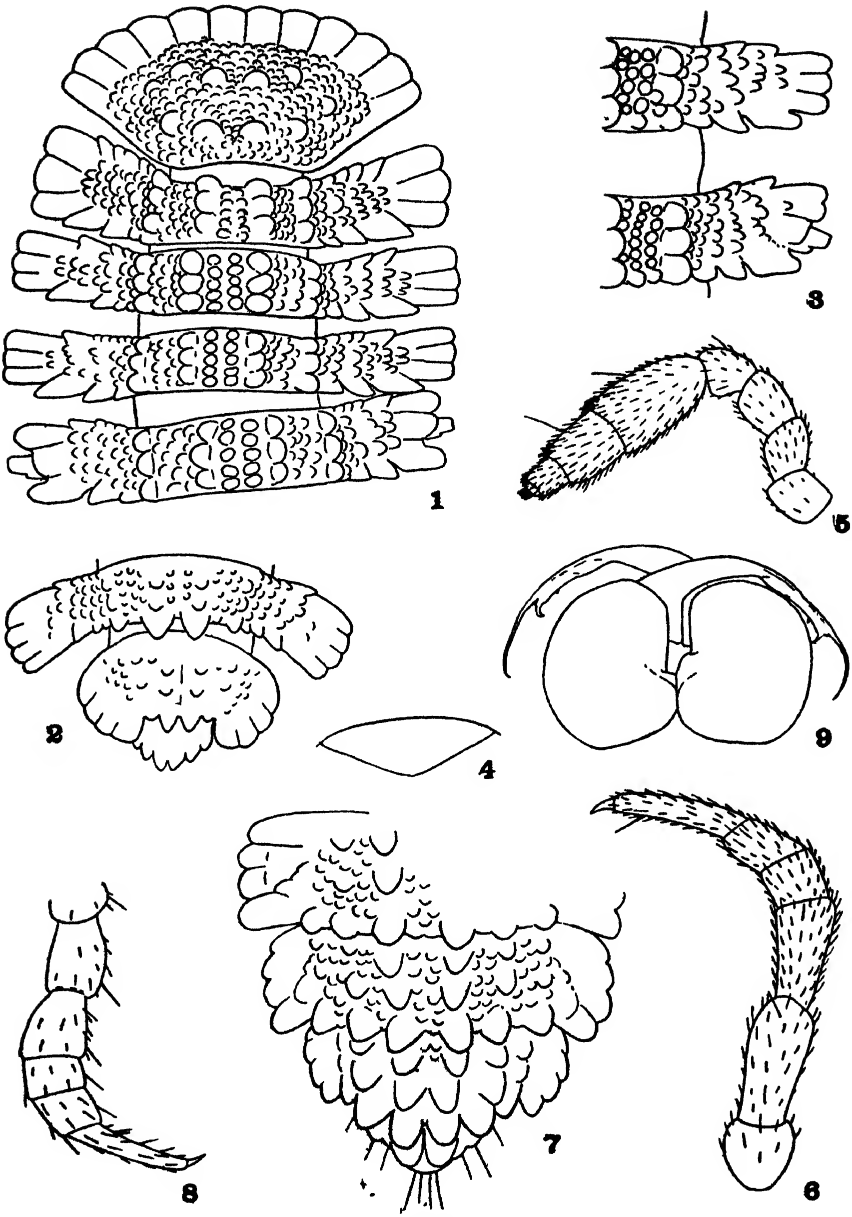


Plate XXVII.

GASATOMUS EMERSONI SP. NOV., *TIDOPTERUS SEQUENS* SP. NOV.

GASATOMUS EMERSONI.—1, anterior end, dorsal view; 2, caudal end, dorsal view; 3, eleventh and twelfth right keels, dorsal view; 4, anal scale; 5, antenna; 6, a leg.

TIDOPTERUS SEQUENS.—7, caudal end of body, dorsal view; 8, leg of eleventh degment; 9, gonopods of male, subventral view.

Gasatomus emersoni sp. nov.

(Plate XXVII, Figures 1 to 6)

Fulvous, appearing brown from adherent foreign material.

Vertex and frons of head densely granular; head smooth below level of antennae. Fifth joint of antennae about one and two-thirds times as long as thick, and not fully twice as long as the sixth article. (Pl. XXVII, fig. 5.)

Border of collum horizontal, its upper surface a little concave; the radial furrows sharply impressed and the corresponding marginal notches pronounced. Central portion of collum strongly convex and densely tubercular, with two transverse rows of larger tubercles as shown in pl. XXVII, fig. 1.)

The keels of the following tergites are trilobed laterally excepting those of the fifth, which are bilobed, and these of the seventeenth, eighteenth and nineteenth, which are four lobed. Caudal margin of keels with two principal lobes separated by narrow incisions, and a minor one proximad of these; the anterior margin with one distinct incision at base of the anterior lateral lobe. On the dorsum between the keels four longitudinal series of enlarged tubercles which greatly exceed the intervening ones in size, the three tubercles of each of these series on each tergite more or less confluent at base. Tubercles of the smaller size are also present on the keels excepting on the lateral lobes. The posterior tubercles of the two submedian principal series on the more caudal tergites are enlarged and project caudad from the plate. See further pl. XXVII, figs. 1 and 2.

Anal tergite with six small lobes or crenuli as shown in pl. XXVII, fig. 2. The anal scale broadly triangular, the caudal angle obtuse. (Cf. pl. XXVII, fig. 4.)

Form and proportions of joints of legs as shown in pl. XXVII, fig. 6.

Length, 7 mm.; width, 1.2 mm.

Locality.—British Guiana, Kartabo, Bartica District. Two females taken Aug. 30, 1920, from nest of *Nasutitermes* (*Subulitermes*) *baileyi* (Emerson).

Tidopterus gen. nov.

Composed of head and twenty segments.

Head nearly wholly covered by the collum from above. Fifth article of antennae but little longer than the sixth.

Border of collum divided by radial sulci and marginal notches into ten lobes.

Keels of succeeding tergites narrower than in Gasatomus, but the lateral margins lobed as in that genus, excepting that the sixteenth as well as the seventeenth, eighteenth, and nineteenth keels, has four marginal lobes. Pores present on segments V, VII, XI, X, XII, XIII, and XV. The pore processes as in Gasatomus as to form and position.

Nineteenth tergite with median caudal border bowed caudad beyond the caudal processes of keels, not forming the bottom of a quadrate excision between the latter. Last tergite exposed from above; bearing two large tubercles which conceal or nearly conceal it from above; margin not caudally incised at middle behind but with crenations, which are typically setiferous, on each side.

Second joint of legs not much differing in length from third, but both the second and third joints shorter than the sixth.

Telopodite of gonopods conspicuously exposed.

Genotype.—*Tidopterus sequens* sp. nov.

Related to Cynedesmus and Gasatomus but differing from both in lacking pores on the sixteenth segment and in the form of the nineteenth and twentieth tergites.

Tidopterus sequens sp. nov.

(Plate XXVII, Figures 7 to 9)

General color flavous.

Head with vertigial and frontal regions densely granular or finely tubercular on each side of the sulcus. The vertex of the head protrudes a little beyond the collum at the middle in

dorsal view. Fifth article of antennae nearly equal in length and thickness; not much longer than the narrower sixth article, the lengths of these articles being about as 5:4.

Border of collum nearly horizontal, narrow, the incisions between the lobes deep. Convex surface densely tubercular, with two transverse rows of larger, well separated tubercles.

Dorsum of the following tergites in general strongly convex and densely tubercular, with four principal longitudinal series of larger tubercles. These higher tubercles are proportionately larger on the more caudal tergites where those at caudal border project conspicuously caudad. The keels are obviously narrower than in the type of Gasatomus, showing but a single lobe on caudal margin; but the lateral lobation and the form and relations of the pore bodies are essentially the same as in that genus.

Anal tergite exposed in dorsal view but its margin concealed, or nearly concealed, in dorsal view by the two large, contiguous, caudally projecting and distally rounded tubercles which it bears. (Cf. pl. XXVII, fig. 7.) Anal scale triangular.

The telopodites of the gonopods of the male are comparatively large and conspicuous. They cross each other at the middle line, each passing in front of and curving back on the outside of the enlarged basal joint of the opposite gonopod. (Cf. pl. XXVII, fig. 9.)

Length, about 6 mm.

Locality.—British Guiana, Kartabo, Bartica District. One male taken, Dec. 18, 1919.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

FROM THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

VOLUME III. NUMBERS 22 AND 23

(Tropical Research Station Contribution Numbers 142 and 143)

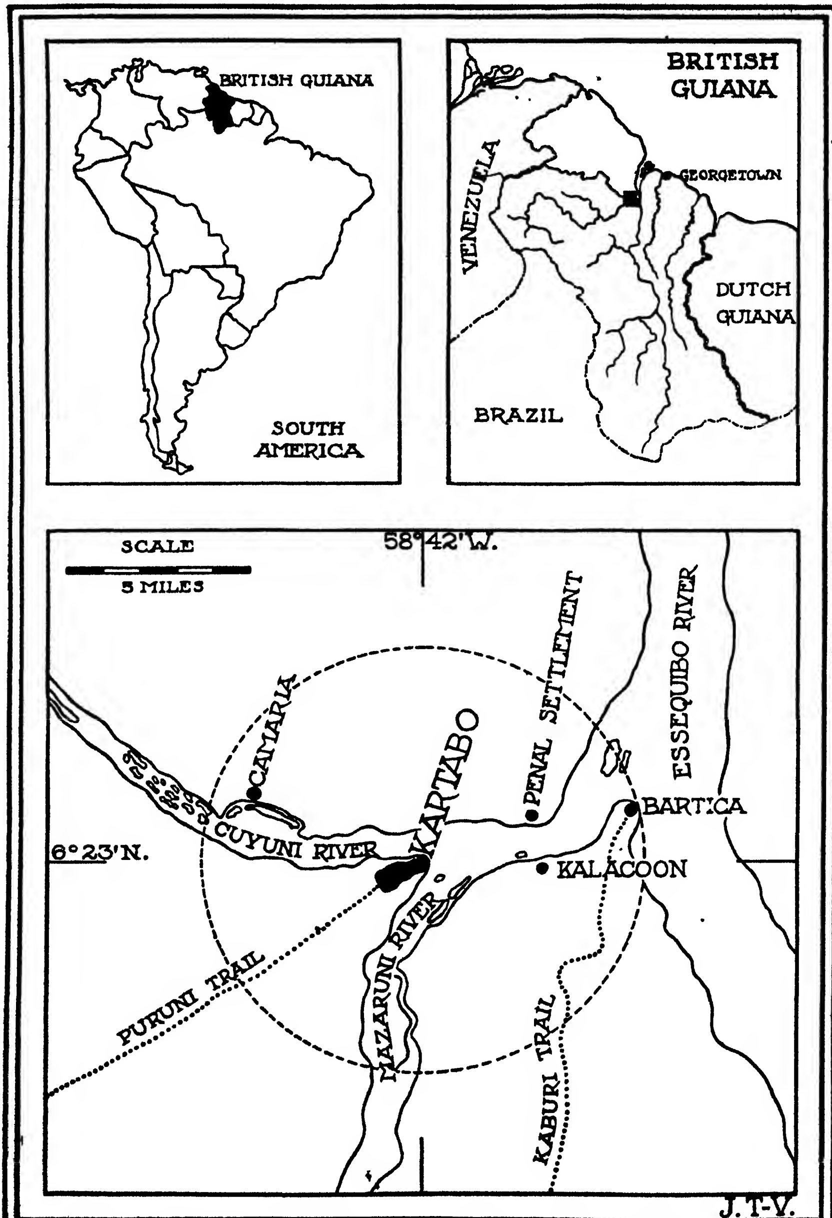
22. A TERMITOPHILOUS BRACONID

23. TWO MYRMECOPHILOUS PHORIDÆ FROM BRITISH GUIANA

By Charles T. Brues

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

October 1, 1923



LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

First form on press October 11, 1923

TERMITOBRACON, A TERMITOPHILOUS BRACONID FROM BRITISH GUIANA[1]*

By CHARLES T. BRUES.

(Figs. 42-43)

In the autumn of 1920, I received from Mr. Alfred Emerson a most extraordinary termitophilous Hymenopteron of the parasitic family Braconidæ. During the course of his extensive studies on termites and the other insects which occur with them, carried on in the vicinity of the tropical station of the New York Zoological Society, at Kartabo, British Guiana, Mr. Emerson obtained specimens of both sexes of this strange insect. From observations on its behavior and the reactions of the termites he assures me that it is undoubtedly a true termitophile and his conviction is fully borne out by its structural characteristics.

The males have the eyes and wings greatly reduced in size and the neuration of the latter are consequently highly modified. From observation Mr. Emerson found that they made no attempts to fly, but moved slowly about the nest among the termites which displayed no hostility, but appeared rather to be friendly toward them. A worker termite was once observed by Mr. Emerson to lick one of the females. The females, in contrast to the males, have the wings fully developed and are undoubtedly able to fly readily. This disparity is in itself very unusual, as there are scarcely any Hymenoptera, or other insects for that matter, in which the females are fully winged and the males apterous or partially so. A similar condition does exist, however, in the fig insects of the family Agaonidæ where the females are winged and the males apterous and a group Idarninæ of a related family of Chalcid-flies, the Calli-

[1] Contribution from the entomological laboratory of the Bussey Institution, Harvard University, No. 184.

* Tropical Research Station, Contribution Number 142.

momidæ, parasitic on the fig insects show a similar condition. Another family of Chalcid flies, the Eulophidæ, contains Melittobia, a widely distributed genus parasitic on various wasps and bees which is subapterous in the male although the female shows no reduction in wing size, while another Eulophid, Perissopterus, parasitic on scale insects, sometimes has subapterous males. In a few other Hymenoptera the male is dimorphic or polymorphic in the development of the wings. Thus the males of a certain species of Pezomachus (*P. flavocinctus* Ashm.) belonging to the Ichneumonidæ have three types of males, a fully winged one, a subapterous one and an entirely wingless one, but in this case the female is apterous. Such is the case also in the Bethylid, *Cephalonomia urichi,* which I have recently shown to have both winged and wingless males. On the other hand the Trichogrammatid Oöphthora has winged females and both alate and apterous males Still more recently Picard has shown that a Braconid (*Sycosoter lavagnei*) parasitic on *Hypoborus ficus* has winged and apterous forms, both sexes being represented by individuals of each type. He has shown further, in this case, that while the four forms occur at the same time, the winged ones are most abundant in warm weather and the wingless ones most numerous in the spring and autumn, while only apterous ones occur during the season of hibernation. Whether the present Braconid may also be dimorphic cannot be stated, but on account of the rarity of such an occurrence, there seems to be no valid reason for assuming that it is.

The male is also much lighter in color than the female, and such is the case also in Melittobia, in at least some of the species.

Most termitophilous insects are physogastric, having the abdomen considerably swollen or enlarged and frequently turned either upwards or downwards, out of the plane in which it normally rests. Termitobracon shows no distinct physogastry in either sex, but the abdomen of the male is perhaps somewhat larger than usual in other male Braconidæ. It is, however, distinctly curved downwards, and when the body is thus partially curled, the aborted wings rest upon its dorsal

surface with their surface bent in conformity to the latter. This bending takes place almost entirely at two points, the base and apex of the stigma.

Termitobracon appears to be the first Hymenopteron ever found as a termite guest[2], and is possibly parasitic upon the termites themselves although it is, of course, quite possible that it may attack some other insect which occurs regularly in their nests. I have examined several thousand termites taken from the nest in which the parasites occured, but have been unable to find any parasitic larvae either in the bodies of the termites, attached to them, or free in the alcohol, so that the host of Termitobracon must remain doubtful. Its size is, however, just about that of the larger termite workers, as might very likely be the case if it should be an internal parasite.

Termitobracon gen. nov.

Female.—Body, including the legs and wings, densely clothed with very fine yellowish hairs. Head strongly transverse; eyes small, hairy; antennae 14-jointed, filiform, the scape short, simple at tip and very closely united with the pedicel; flagellum beyond the third joint marked by fine longitudinal ridges, the first three joints strongly emarginate at tip; ocelli minute, in a small triangle; clypeus semicircular, not emarginate, not horned nor toothed; mandibles small, acute, without teeth near apex. No parapsidal furrows; propodeum simple, convex. Abdomen short, oval, with seven well developed segments, first segment with lateral carinae, but otherwise not sculptured; ovipositor issuing near the middle of abdomen, but not extending far beyond the apex, sheaths slender, but dilated near the apex. Legs rather stout, the basal and apical joints of tarsi elongated, the others very short. Wings rather large,

[2] Since this was written Cushman (Proc. Entom. Soc. Washington, vol. 25, p. 54, 1923), has described a genus of Braconidæ, Ypsisterocerus, represented by two species collected in termite nests by Dr. W. M. Mann in Bolivia. Ypsistrocerus and Termitobracon are quite closely related, but differ in a number of good structural characters in spite of the fact that both occur in the nests of the same species of termite. Cushman has made Ypsistrocerus the type of a new subfamily (Ypsistrocerinae) to which Termitobracon must now be added.

stigma broad, dark, but not heavily chitinized, the radial cell broad, attaining the wing tip; three cubital cells although the transverse cubiti are in great part hyaline; nervulus strongly postfurcal; nervellus interstitial; hind wing without nervulus or marginal vein.

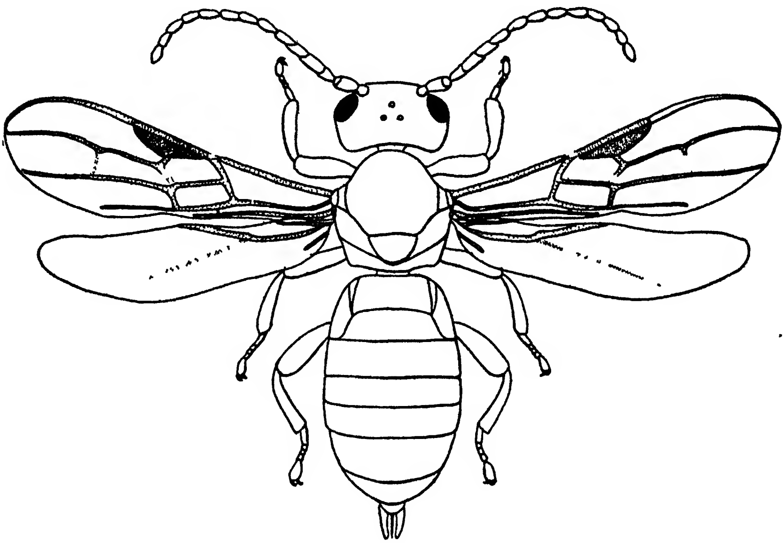


FIG. 42. *TERMITOBRACON EMERSONI* SP. NOV.
Female.

Male.—Subapterous, the wings greatly reduced in size, curved over the abdomen at rest and distinctly bent at each end of the stigma, reaching just beyond middle of abdomen. Eyes minute, ocelli wanting. Legs stouter than those of the female. Color of body much lighter.

Type, the following species:

Termitobracon emersoni sp. nov.

(Figs. 42-43)

Female (Fig. 42).—Length 2.2-2.3 mm. Fuscous, the head black, except about the mouth; thorax distinctly darker than the abdomen, especially in front above; legs brownish yellow, the tibiae and tarsi lighter than the femora. Antennae yellowish,

the first three joints of flagellum much darkened and the last seven joints very pale; clypeus and mandibles, except their black tips, honey-yellow; propleura on anterior edge and spot on mesopleura below, yellow; propodeum anteriorly and at the sides stained with yellow; abdomen darker at the sides of the first segment and along the posterior margins of the second and fourth segments; ovipositor black, its sheaths pale; wings brownish-hyaline, a weak cloud in the upper part of the radial cell; venation dark fuscous. Head two and one half times as broad as thick antero-posteriorly, rounded and narrowed behind the eyes, which are broadly oval, quite small, as long as the

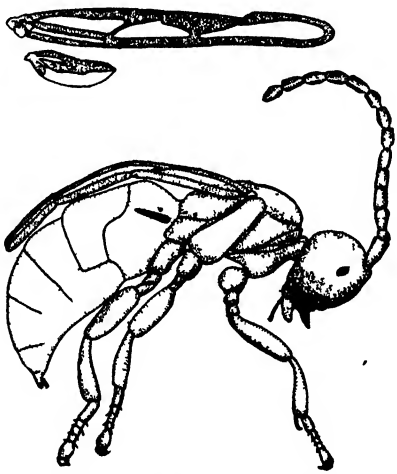


FIG 43 *TERMITOBRACON EMERSONI* SP NOV
Male

scape of the antenna; antennae 14-jointed; scape short, the pedicel closely attached to it, rounded; first joint of flagellum short, second to fourth longer, about twice as long as broad; following quite distinctly oval the last pointed at tip. Malar space twice as long as the eye; surface of head smooth; ocelli forming an equilateral triangle. Mesonotum and scutellum smooth and shining, not very strongly convex. Propodeum smooth above, without sculpture. First abdominal segment carinate at the sides, the space between the carinae twice as broad as long; surface smooth and polished as is the remainder of the abdomen; second and third segments of equal length,

together as long as broad, the articulation between them very faint; fourth and fifth segments equal in length and width, each slightly shorter and broader than the third; sixth much longer and narrower; seventh half the length of the sixth; eighth minute; ovipositor but slightly exserted. First section of radius very short; one-fourth as long as the second which is slightly shorter than the third; radial cell attaining the wing tip; cubitus arising at the middle of the basal nervure, the transverse cubiti not complete, the first pigmented, except below, the second indicated by the absence of trichiation; nervulus entering near the middle of the discoidal cell; nervellus interstitial; hind wing with only the basal and submedian vein and a stump of the anal, nervulus wanting; subdiscoidal indicated as a faint cloud extending to the wing margin.

Male (Fig. 43).—Length 1.9 mm. Almost entirely light testaceous, the head blackened above, the carinae on the first abdominal segment black and the hind margins of the third to fifth segments infuscated. Eyes much smaller, scarcely as long as the diameter of the pedicel of the antennae.

Four females and three males from Kartabo, British Guiana, collected by Mr. Alfred Emerson in a nest of *Nasutitermes* (N.) *ephratae* (Holmgren), July 28, 1920.

Mr. Cushman has kindly compared a specimen of Termitobracon with the unique types of his two species of Ypsistrocerus and considers the two genera to be undoubtedly closely related in spite of many obvious differences, some of which may be tabulated as follows:

Maxillary palpi 2-jointed; labial palpi apparently wanting; joints of the filiform antennal flagellum all of similar form; first and second cubital cells fused (female); Stigma narrow (female) ....Ypsistrocerus Cushman.

Maxillary palpi 3-jointed; labial palpi 2-jointed; basal three joints of antennal flagellum each with an oblique emargination at apex, following joints oval; first and second cubital cells separated (female); Stigma broad (female) ....Termitobracon Brues.

TWO MYRMECOPHILOUS PHORIDÆ FROM BRITISH GUIANA[1]*

By CHARLES T. BRUES

(Fig. 44).

In September, 1920, Mr. William Beebe, director of the Tropical Research Station of the New York Zoological Society at Kartabo, British Guiana, in company with Mr. Alfred Emerson, obtained two remarkable species of Phoridæ along the trails of the legionary ant, *Eciton burchelli.* This ant is abundant in the region of the Station and like the other species of the genus undoubtedly harbors many myrmecophilous insects of various kinds.

On examining the specimens, which they kindly sent me for study, I find that one form represents a new genus, quite different from any of those heretofore described and that the second is identical with a species first made known only a few years ago from Southern Brazil, where it was found with another species of Eciton having somewhat similar habits.

As is the case with many of the myrmecophilous Phoridæ, only the wingless or subapterous female of these two species has so far been obtained.

Apterophora gen. nov.

Female.—Wingless, but with the eyes large, half as high as the side of the head; ocelli present; antennæ small, round; palpi simple, with stout bristles at apex; proboscis slender, four times as long as the head-height, geniculate at the middle, with the apical half directed forward. Three transverse series of frontal setæ, the lowest two proclinate, close together; a pair just above these erect or slightly proclinate; upper row of four, two of which are next to the ocelli. Head, seen from above,

[1] Contribution from the entomological laboratory of the Bussey Institution, Harvard University, No. 185.

* Tropical Research Station, Contribution Number 143.

much produced medially in front. Dorsum of thorax somewhat wider than long, no scutellum; a large humeral bristle on each side and a posterior row of stout bristles; pleura oblique, fully twice as high as the length of the dorsum. Abdomen with five very heavily chitinized black dorsal plates which are only slightly separated by pale membrane in engorged specimens; ventral surface membraneous, nearly white, without any chitinous plates. Legs rather slender, the anterior coxæ as long as the femora; all tibiæ without preapical spines or bristles.

Type *Apterophora caliginosa* sp. nov.

This is similar to Enderlein's genus Crepidopachys (Enderlein '12) from Southern Brazil on account of its long proboscis, but the type of this is a winged insect and it is difficult to make further comparisons. The sex is not given by Enderlein, and if his description should apply to a male, the genus might be related to the present one. I suspect that his examples were females, however, from the description of the apex of the abdomen and particularly the long proboscis, in spite of the fact that the greatly thickened costa suggests that they might be males. Even if the latter should be the case, I do not believe that the two could possibly be congeneric or even closely related, as the long proboscis is the only striking similarity.

Among the genera known to have wingless or subapterous females, two have a similarly lengthened proboscis. Psyllomyia Loew (Loew '57, Wassman '00; Brues '01; Schmitz '14) a guest in the nests of *Dorylus helvolus* in South Africa has a long, slender, geniculate proboscis which is, however, not much longer than the head. It has also a dark, heavily chitinized abdomen like Apterophora, but the wings are present as large broad pads. The eyes are much smaller, the ocelli absent, and the legs very stout in Psyllomyia. In the absence of males, therefore, it seems unwise to regard them as possibly congeneric.

Rhynchomicropteron Annandale (Annandale '12; Schmitz '14 and '15) known by two species, one from Ceylon as a guest of *Lopopelta ocellifera* Rog. and another from Bombay as a guest of *Prenolepis longicornis* Latr., is very similar in some respects to Apterophora; it has a very long, slender, geniculate

proboscis and a similarly formed head and thorax. It differs greatly in having well developed digitiform wing pads, in having the ocelli absent, and is practically blind, as the compound eyes are mere vestiges, each composed of half a dozen separate ommatidia. The most striking differences are seen in the abdomen which is entirely membranous, without any clearly chitinized plates, and in the dorsum of the mesothorax which bears a longitudinal impression and distinct median suture, something of very rare occurrence in insects.

Apterophora caliginosa sp. nov.

(Fig. 44).

Female.—Length 1.7-1.9 mm. Head, thorax, abdominal plates, and four posterior coxæ deep, shining black; legs and proboscis honey-yellow; antennæ pale yellow; palpi fuscous; membranous parts of abdomen white, with a slightly sooty tinge. Head distinctly wider and longer than the thorax, the front obtusely triangularly produced between the antennæ, frontal bristles well developed, but not very strong. Eyes oval, contiguous, with the antennal excavation and the posterior margin of the head; cheek one-third the height of the eye, each with a tuft of four or five small bristles anteriorly above the insertion of the palpus, but without bristles behind; postocular bristles weak. Antennæ round, small, with apical, strongly pubescent arista which is one-third longer than the head-height. Proboscis stout at the base, but narrowed and very slender beyond; geniculate just before the middle, the basal part straight, at rest bent somewhat beneath the body and extending to the tip of the front coxæ; apical part curved, projecting forward with the upper margin convex; tip obliquely truncate, with a few minute bristles. Palpi with a few moderately large bristles below near apex. Surface of head impunctate. Mesonotum one-fourth wider than long; anterior margin arcuately excavated, the humeri rounded; spiracles visible from above, just behind the humeri; posterior margin slightly convex. Macrochaetæ not strong, disposed as follows: a weak post-humeral one, a series of six longer ones along the posterior margin, one at each extreme lateral angle and four between these, the

median two farther apart than the others. Surface indistinctly punctate. Abdomen highly convex above, the plates densely and finely punctate; first (visible) one the largest, nearly three times as long and wide as the mesonotum, almost twice as broad behind as in front, the posterior margin nearly straight and fringed with long, bristle-like hairs; second plate only half

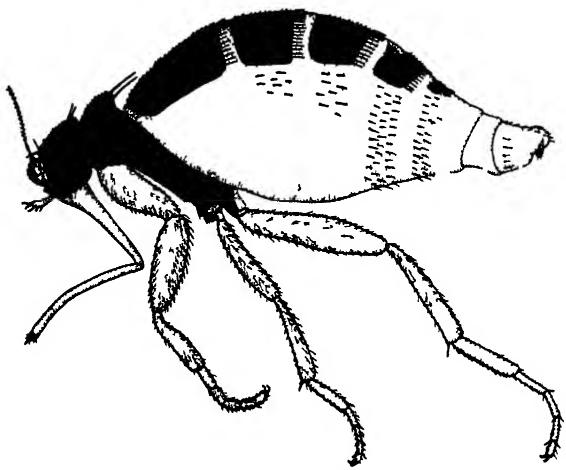


FIG 44. *APTEROPHORA CALIGINOSA* SP NOV

as long as the preceding, but of equal width, similarly punctate and fringed along the posterior margin; third distinctly shorter and narrower, fringed; fourth (really the fifth) segment smaller, the gland opening filling a large anterior emargination of the plate; fifth very small, not fringed like the others; apex of abdomen of the usual tubular, retractile form. All of the abdominal plates clothed with fine, pale, glistening pubescence. Legs slender, although the anterior tibiæ are slightly thickened; spurs of four posterior tibiæ small, but distinct; hind metatarsi each with seven transverse rows of dense fine recumbent bristles.

Described from two specimens, both the type and paratype, as well as several other specimens which I have not examined, taken at the same time near a trail of the army ant, *Eciton burchelli,* at Kartabo, British Guiana. Concerning their relationship to the ants, Mr. Emerson writes that the first specimen

was seen by Mr. Beebe in the ant trail and that further careful search was rewarded by the finding of several others.

ECITOPHORA COMES SCHMITZ.

Zool. Jahrb. Abth. f. Syst., vol. 36, p. 524 (1914).
Brues, Psyche, vol 30, p. 21 (1923).

Three females from Kartabo, British Guiana taken at the same time that the previous Phorid was obtained, prove to belong to this species.

The types were found with *Eciton predator* Sm. at São Leopoldo, Rio Grande do Sul in southern Brazil, but the Guiana examples agree in all details with Schmitz's description and excellent figures.

It is evident, therefore, that this myrmecophile is widely distributed in tropical South America and that it occurs with at least two species of Eciton, *E. burchelli* and *E. predator.*

Ecitophora is much like Ecitomyia Brues, with which Schmitz has compared it, and differs in only a few details. In view of the numerous monotypic genera in this group and as Schmitz has already erected the genus Ecitophora for this species I have used the name although I am by no means satisfied that the two genera can be maintained. Nevertheless Ecitophora is readily separable by the presence of ocelli and the complete absence of the plate on the third abdominal segment, although the minute fourth and fifth plates are fully chitinized and fully colored.

BIBLIOGRAPHY

ANNANDALE, N.

1912. A Micropterous Fly of the Family Phoridæ Associated with Ants. Spolia Zeylandica, vol. 8, pp. 85-89, pl. 1

BRUES, C. T.

1901. Two New Myrmecophilous Genera of Aberrant Phoridæ from Texas. American Natural, vol. 35, pp. 337-356, 11 figs.

ENDERLEIN, G.

1912. Die Phoriden Süd-Brasiliens. Stettiner Entom. Zeitg., pp. 16-45, 2 figs.

LOEW, H.

1857. *Psyllomyia testacea,* eine neue Gattung der Phoriden. Wiener Entom. Monatsscher., vol. 1, pp. 54-56, 1 pl., 22-25 figs.

SCHMITZ, H.

1914. Die myrmecophilen Phoriden der Wasmann'schen Sammlung. Zool., Jahrb., Abth. f. Syst., vol. 37, pp. 509-566, 11 figs., 2 pls.

1915. Berichtigung und Ergänzungen zu den "Myrmecophilen Phoriden der Wassmannschen Sammlung." Schmitz 1914. Deutsch. Entom. Zeitschr., vol. 5, pp. 503-504.

WASMANN, E.

1900. Neue Dorylinengäste aus dem neotropischen und dem äthiopischen Faunengebiet. Zool. Jahrb., Abth. f. Syst., vol. 14, pp. 215-289, 2 pls.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

INDEX TO

VOLUME III

SEPTEMBER 1921–1923 OCTOBER

NUMBERS 1–23 INCLUSIVE

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

1925

Index

Date of issue	Date of issue	Date of issue

GIPN—S1—54 I.A.R.I. 56—22-1-57—1,000